CH2M HILL
1748 West Truck Road
Otis ANGB, MA 02542

31 March 2010

Mr. Jonathan S. Davis
Remediation Program Manager
HQ AFCEE/MMR
322 E. Inner Road
Otis ANG Base, MA 02542-5028

SUBJECT: AFCEE 4P08 FA8903-08-D-8769; Task Order 0148
MMR SPEIM/LTM/O&M Program
CDRL #A001l
Fuel Spill-1 2009 Summary Letter Report

Dear Mr. Davis:

The purpose of this Summary Letter Report (SLR) is to document the results of sampling activities conducted at the Fuel Spill-1 (FS-1) plume under the System Performance and Ecological Impact Monitoring (SPEIM) program during the 2009 calendar year. This deliverable contains no detailed assessment or evaluation of the results, but is a means of documenting all the actions completed under the FS-1 SPEIM program. The data collected under the SPEIM program are continually assessed and the results of these assessments are presented initially during the Technical Update Meetings and then through Technical Memoranda or Project Note deliverables, if warranted, based on the results of the data evaluation or to address particular plume issues.

This letter report includes a summary of the activities performed and the data collected for the FS-1 SPEIM program between 01 January 2009 and 31 December 2009. The FS-1 plume is defined as the extent of groundwater contaminated with ethylene dibromide (EDB), the FS-1 plume contaminant of concern (COC), at concentrations exceeding the Massachusetts Maximum Contaminant Level (MMCL) of 0.02 micrograms per liter (µg/L). Lead, thallium, and toluene are COCs for the FS-1 source area groundwater (AFCEE 2000). However, the source area groundwater is no longer sampled for toluene and thallium because toluene has not been detected at concentrations above the MCL since 1999 and thallium has not been detected at source area groundwater monitoring wells (AFCEE 2005).

The FS-1 extraction, treatment, and discharge (ETD) pilot system operated between 05 April 1999 and 13 October 2002, when a fire consumed the treatment plant. The pilot ETD system was designed for a combined extraction rate of 750 gallons per minute (gpm) from the aquifer using one extraction well (36EW0005) and 175 shallow wellpoints (SWPs) located in the southern portion of the plume. The Air Force Center for Engineering and the Environment (AFCEE) designed the final FS-1 ETD system under a Final Record of Decision (AFCEE 2000), with the selected alternative modified as described in the final wellfield design report (AFCEE 2001).

The final ETD system began operating on 30 September 2003 (AFCEE 2005). It was designed to extract 750 gpm from the aquifer using four extraction wells (36EW0001, 36EW0005, 36EW0007, and 36EW0011) located in the south south-central portion of the plume. The FS-1 plume and treatment system are presented in **Figure 1**. The southernmost extraction well (36EW0001) replaced the SWP system, which was decommissioned in November 2003 (AFCEE 2005). The extracted groundwater is conveyed to the treatment plant where it is treated by a granular activated carbon system and discharged to the K1 and K2 bog ditches via three vertical riser pipes (i.e., bubblers). The FS-1 ETD system was optimized in 2007 (2007 Scenario 01), which entailed turning off 36EW0007 and adjusting flows at the remaining three extraction wells, and resulted in a new total extraction rate of 515 gpm (AFCEE 2007). During 2009, the FS-1 ETD system operated under pumping configuration 2007 Scenario 01.

FS-1 SPEIM ACTIVITIES

The SPEIM program was developed to monitor plume changes and to ensure the effective operation of AFCEE groundwater remediation systems at the Massachusetts Military Reservation (MMR). These objectives are met through monitoring of selected media (i.e., groundwater, surface water) within and outside the plume boundaries, treatment plant monitoring, and groundwater flow and transport modeling. Activities completed for the FS-1 SPEIM program during 2009 include the following:

SPEIM Sampling Activities:

- Annual and triennial groundwater sampling for EDB analysis (June 2009).
- Biennial sampling for total Lead (June 2009).
- Surface water sampling at the Quashnet River bog complex (May, July, and September 2009).
- Semiannual extraction well sampling (June 2009 and December 2009).
- Additional sampling of 36MW1001B, which is located to the south of the FS-1 ETD system hydraulic capture zone. Sampling of this well was completed to provide for temporary short-term monitoring of an EDB MMCL exceedance first reported at 36MW1001B in June 2008 (December 2009).
- Monthly treatment plant sampling (January 2009 through December 2009)
- Recording of daily average treatment system flow rates (January 2009 through December 2009)
- Hydraulic monitoring was not needed at FS-1 during 2009.

The groundwater and surface water locations sampled for the FS-1 SPEIM program in 2009 are presented in **Figure 2** and **Figure 3**, respectively. The well construction and surface water sample location information is included in **Table 1**. The current approved FS-1 SPEIM network, including analytical scope and methods, is presented in the *Comprehensive Long Term Monitoring Plan*, which is available on-line at www.mmr.org under Plans and Protocols.

Groundwater analytical results are presented in **Table 2**. **Table 3** contains the surface water analytical results. A map showing the distribution of EDB detections in groundwater is included as **Figure 4**. A comparison of all compounds detected in groundwater, surface water, and treatment plant samples to applicable standards is included in **Attachment A**.

Drilling and Direct-Push Activities:

No drilling or direct-push sampling was completed at FS-1 in 2009.

Data Summary Report:

The data summary reports for the analytical data reported in this SLR are included in **Attachment B**. **Attachment B** also includes a Corrective Action Report associated with the reporting of EDB data collected between June and August 2009. It was determined that the analytical laboratory was not reporting EDB detections at estimated concentrations below the reporting limit for some of the samples. The affected EDB results were corrected and re-reported by the laboratory. This EDB reporting issue had no impact on the decision making process under the SPEIM/Operations and Maintenance Program at FS-1. A summary of the affected data and project impacts is provided in Table 1 of the Corrective Action Report.

Presentations:

Presentations for the FS-1 plume are listed in **Table 4**.

Project Note Submittals:

The project notes related to activities conducted for the FS-1 plume under the SPEIM program in 2009 are included in **Attachment C**.

Report Submittals:

- *Fuel Spill-1 2008 Summary Letter Report* (March 2009)

Major Events and Optimizations:

A modeling-based optimization evaluation for a cyclic pumping remedial approach at the FS-1 ETD system was completed in 2009 (AFCEE 2009). A cyclic pumping approach entailed periodic pumping of extraction wells for durations of at least one week or greater in an effort to optimize the operation of a groundwater extraction system by taking advantage of natural hydraulic gradients to transport contamination to the extraction wells, while still maintaining the remedial objectives of the system as a whole.

Model simulations of cyclic pumping of the FS-1 ETD system resulted in similar EDB mass removal estimates but with lower annual electrical costs than those predicted for the current continuous pumping scenario (2007Scenario 01). However, these electrical savings are offset by the longer operational times required for each extraction well and the ETD system as a whole in order to achieve model-predicted aquifer restoration. Therefore, cyclic pumping strategy was not instituted at FS-1, at this time. Although cyclic pumping did not appear to have immediate benefits at the FS-1 groundwater plume, this general pumping strategy will be evaluated at other MMR plumes.

FS-1 REMEDIAL STATUS UPDATE

Analytical results from the FS-1 treatment plant sampling are presented in Table 5. Average weekly flow rates for the FS-1 extraction wells are presented in Table 6. Treatment system operational downtimes or deviations (for events lasting two hours or longer) for 2009 are summarized in Table 7. Mass removal calculations through December 2009 for the FS-1 treatment plant are presented in Table 8.

The most recent plume shell for the FS-1 plume included data collected through June 2006. The 2006 FS-1 plume shell is estimated to contain approximately 459 million gallons of groundwater contaminated with EDB concentrations above the MMCL and approximately 1.15 pounds (lbs) of dissolved-phase EDB at concentrations above the MMCL. The FS-1 ETD system removed approximately 0.2 lbs of EDB between January 2009 and December 2009. During this period, approximately 264 million gallons of groundwater was treated at the FS-1 treatment plant. The operation of the FS-1 remedial system used approximately 259 megawatt hours of electricity during 2009. Power plant air emissions associated with this power generation for 2009 and since system startup in April 1999 are presented in Table 9. Green energy purchases and power production from the 1.5 megawatt wind turbine, which started operation on 02 December 2009, are incorporated into these air emissions data.

The FS-1 ETD system is currently operating with the 2007 Scenario 01 flow rates (AFCEE 2007). Using the 2006 EDB plume shell and assuming that the system will operate continuously at the 2007 Scenario 01 flow rates, groundwater modeling results predict that the ETD system will continue to capture EDB until approximately 2020. However, a small pod of low concentration EDB plume is predicted to remain in a basal silt at FS-1 through the last simulation time-step of 2031 (AFCEE 2007). Through the SPEIM program, remedial system operation is continuously evaluated and optimized to reduce cleanup times, therefore the timeframes presented in this section will most likely be decreased in future scenarios.

FS-1 SPEIM ACTIVITIES PLANNED FOR 2010

Activities currently planned for the FS-1 SPEIM program for 2010 include the following:

- Field data gap investigation to include groundwater vertical profiling for EDB at up to three boring locations (Spring 2010)
- Update of EDB plume shell using data collected during the proposed field data gap investigation and regular SPEIM monitoring (Summer 2010).
- Biennial/annual groundwater sampling (June 2010)
- FS-1 biennial/annual SPEIM data presentation
- Semiannual sampling of operating extraction wells (June 2010 and December 2010)
- Optimization of the FS-1 SPEIM chemical monitoring network based on a review of field data gap and SPEIM monitoring data.
- Surface water sampling (May, July, and September 2010)
- Monthly treatment plant sampling (January 2010 through December 2010)

- Recording of daily average treatment system flow rates (January 2010 through December 2010)
- Synoptic water level measurements (as needed)
- Land use control private well verification surveys and sampling (as needed).

If you have any questions or comments, please contact Mike Minior at (508) 968-4670, extension 4672.

Sincerely,

CH2M HILL

Patricia de Groot, P.G.
Program Manager

Attachments:

Figure 1	FS-1 Groundwater Plume and Treatment System
Figure 2	FS-1 Chemical Monitoring Locations
Figure 3	FS-1 Surface Water Chemical Monitoring Network
Figure 4	FS-1 2009 Ethylene Dibromide Detections in Groundwater
Table 1	FS-1 Well Construction and Surface Water Sampling Location Information
Table 2	FS-1 Groundwater Monitoring Results
Table 3	FS-1 Surface Water Monitoring Results
Table 4	FS-1 Meeting Presentations
Table 5	FS-1 Treatment Plant Sampling Results
Table 6	FS-1 Treatment System Flow Rates
Table 7	FS-1 Treatment System Downtime Summary
Table 8	FS-1 Treatment System Mass Removal Summary
Table 9	FS-1 Remedial System Electrical Consumption and Associated Air Emissions
Attachment A	Comparison of Detected Concentrations in FS-1 Groundwater and Surface Water to Applicable Groundwater and Surface Water Standards
Attachment B	FS-1 2009 SLR Data Summary Reports
Attachment C	FS-1 Project Notes

* c: Mike Minior, AFCEE/MMR
Rose Forbes, AFCEE/MMR
Leticia Walton, AFCEE/ACR
Paul Marchessault, EPA
Leonard Pinaud, MassDEP
Peter Golonka, GF
James Quin, Aerostar Environmental
Denis LeBlanc, USGS
Glen Harrington, Mashpee BH
Martha Steele, DPH
Drew McManus, Mashpee Consv.
Jeff Lafleur, Cape Cod Cranberry Growers Assoc.
Phil Brady, MA Div. of Marine Fisheries
Bill Fisher, Haley & Aldrich
Brian Handy, Handy Cranberry Trust
Steve Hurley, MDFW
CH2M HILL Doc. Control & Distribution

* Delivery via email notifying recipients of availability of electronic document at www.mmr.org.

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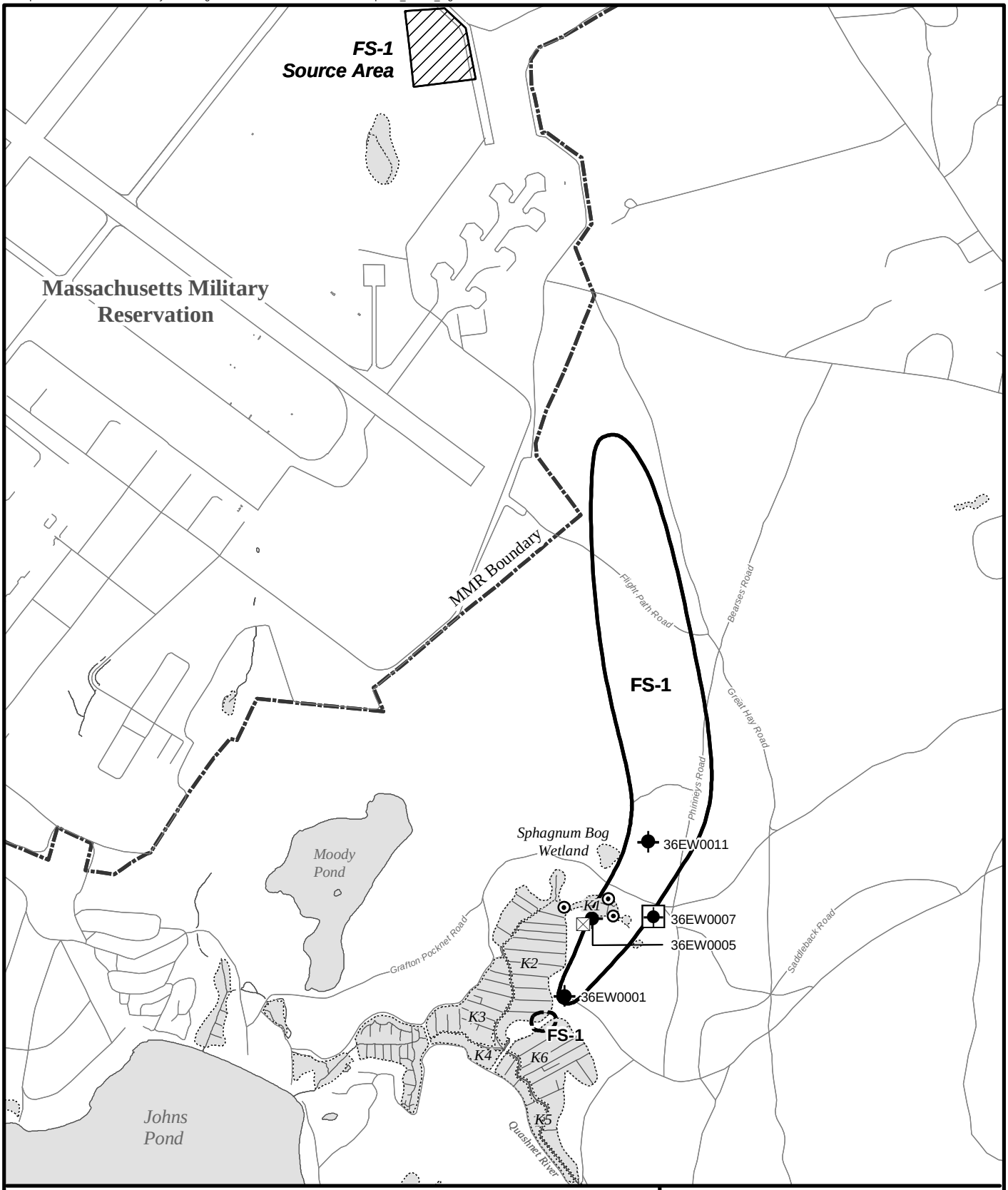
FIGURES



Legend

Data Source: AFCEE, February 2010, MMR-AFCEE Data Warehouse

- Outflow Bubbler
- Extraction Well (On)
- Extraction Well (Off)
- Treatment Plant
- Massachusetts Military Reservation Boundary
- Plume Boundary (Dashed Where Inferred)
- Bog/Wetland
- Source Area

N

0 600 1,200 Feet

FIGURE 1

FS-1 GROUNDWATER PLUME AND TREATMENT SYSTEM

AFCEE - Massachusetts Military Reservation

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FS-1 Source Area

36MW0007

36MW0002

Mashpee Pond

Baker's Rd

Ashumet Rd

36MW1036A,B,C

Bearses Rd

Reilly

36MW1043A,B

36MW0501

36MW0504

MMR Boundary

FS-1

36MW1041A,B,C

36MW1040A,B

36MW1038A,B,C

Great Hay Rd

Bookers Rd

36EW0011

Moody Pond

Grafton Pocknet Rd

36MW1010A,B,C

36PZ1010

36PZ1003

36MW1003A

36EW0005

36MW0140

36MW1014A,B

36MW0131A,B,C

36EW4020

Vernal Pool

36MW1012A,B,C

Saddleback Rd

Quashnet Rd

Lovells Ln

36PZ1002A,B

36MW0132A,B,C

36EW0001

K3

36EW4084

36PZ1001

36MW1001A,B

36EW4135

Back Rd

K4

FS-1

Quashnet River

36MW0143

K6

36MW1011A,B

K5

Johns Pond

Legend

- Monitoring Well
- Piezometer
- Extraction Well
- Bog/Wetland
- Source Area
- Plume Boundary (Dashed Where Inferred)
- Massachusetts Military Reservation Boundary

Data Source: AFCEE, February 2010, MMR-AFCEE Data Warehouse

N

0 390 780

Feet

FIGURE 2

FS-1 CHEMICAL MONITORING LOCATIONS

AFCEE - Massachusetts Military Reservation

FS-1 2009 Summary Letter Report

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Legend

- Surface Water Sampling Location
- Bubbler
- Bog/Wetland
- Plume Boundary (Dashed Where Inferred)

Data Source: AFCEE, March 2010, MMR-AFCEE Data Warehouse

N

0 150 300 Feet

FIGURE 3

FS-1 SURFACE WATER CHEMICAL MONITORING NETWORK

AFCEE - Massachusetts Military Reservation

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36MW1036A,B,C
36MW1043A,B
36MW0501
36MW0504
FS-1
36MW1041A,B,C
36MW1040A,B
36MW1038A,B,C
36EW0011
36MW1010A,B,C
36PZ1010
36PZ1003
36MW1003A
36MW1014A,B
36EW0005
36MW0140
36MW0131A,B,C
36EW4020
36MW1012A,B,C
36PZ1002A,B
36EW0001
36MW0132A,B,C
36EW4084
36PZ1001
36MW1001A,B
36EW4135
36MW0143
36MW1011A,B
MMR Boundary
Moody Pond
Quashnet River
K1
K2
K3
K4
K5
K6
Great Hay Rd
Bearses Rd
Bookers Rd
Grafton Pocknet Rd
Ashers Path
Saddleback Rd
Quashnet Rd
Boghouse Rd
Phinneys Rd

Legend

- Extraction Well
- Plume Boundary (Dashed Where Inferred)
- Massachusetts Military Reservation Boundary
- Bog/Wetland

Contaminant Detections in Groundwater:

- No Detection
- Detection Below or at MMCL
- Detection Above MMCL

Data Source: AFCEE, February 2010, MMR-AFCEE Data Warehouse

N

0 225 450 Feet

FIGURE 4

FS-1 2009 ETHYLENE DIBROMIDE DETECTIONS IN GROUNDWATER

AFCEE - Massachusetts Military Reservation

FS-1 2009 Summary Letter Report

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TABLES

Table 1
FS-1 Well Construction and Surface Water Sampling Location Information
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Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
36EW0001 (1)	233941	871784	56.44	50.46	191	-5.22	-129.37	124
36EW0005 (2)	234603	872017	39.91	38.40	191	-84.39	-146.09	62
36EW0011 (3)	235254	872496	93.53	87.43	249	-88.64	-150.63	62
36EW4020 (4)	234368	871812	36.19	36.44	21	19.19	16.19	3
36EW4084 (4)	233801	871670	35.14	35.39	21	17.64	14.64	3
36EW4135 (4)	233665	871854	34.38	34.63	20	17.38	14.38	3
36MW0002	241852	870832	105.75	108.75	56	59.29	49.29	10
36MW0007	241934	870793	107.20	110.14	56	61.20	51.20	10
36MW0131A	234440	872236	52.15	54.39	186	-127.85	-132.85	5
36MW0131B	234440	872228	53.37	55.25	139	-80.63	-85.63	5
36MW0131C	234439	872228	53.37	55.30	90	-31.63	-36.63	5
36MW0132A	233922	871754	54.30	53.96	190	-130.70	-135.70	5
36MW0132B	233922	871754	54.30	53.96	140	-80.70	-85.70	5
36MW0132C	233936	871754	54.61	53.98	83	-23.39	-28.39	5
36MW0140	234665	872715	50.44	50.16	140	-84.56	-89.56	5
36MW0143	233279	871161	34.94	34.68	170	-130.06	-135.06	5
36MW0501	237066	872994	78.38	78.03	150	-66.62	-71.62	5
36MW0504	236799	871836	78.85	78.46	182	-98.15	-103.15	5
36MW1001A	233707	871589	34.48	33.36	150	-110.52	-115.52	5
36MW1001B	233701	871582	34.63	34.13	100	-60.37	-65.37	5
36MW1003A	234670	871920	36.49	36.10	154	-112.61	-117.61	5
36MW1010A	234896	872068	49.37	51.62	231	-171.13	-181.13	10
36MW1010B	234922	872071	50.63	49.95	165	-109.37	-114.37	5
36MW1010C	234896	872068	49.37	51.64	86	-31.13	-36.13	5
36MW1011A	233120	871376	34.62	33.88	100	-60.38	-65.38	5
36MW1011B	233131	871368	34.84	34.45	25	14.84	9.84	5
36MW1012A	234298	871824	38.04	37.24	149	-106.06	-111.06	5
36MW1012B	234304	871825	38.10	37.64	78	-34.80	-39.80	5
36MW1012C	234304	871825	38.10	37.72	23	20.50	15.50	5
36MW1014A	234611	871830	36.37	36.17	99	-57.13	-62.13	5
36MW1014B	234607	871829	36.16	35.98	23	18.06	13.06	5
36MW1036A	238793	872114	107.97	107.37	263	-150.03	-154.98	5
36MW1036B	238790	872105	107.85	107.09	224	-111.05	-116.05	5
36MW1036C	238793	872115	107.97	107.37	176	-62.18	-67.13	5
36MW1038A	235573	872357	96.76	96.56	245	-142.94	-147.84	5
36MW1038B	235567	872350	96.95	96.18	204	-102.15	-106.95	5
36MW1038C	235578	872363	96.55	96.05	94	7.45	2.65	5
36MW1040A	235648	872945	64.54	64.32	219	-149.18	-153.98	5
36MW1040B	235647	872953	64.49	64.19	134	-63.99	-68.82	5
36MW1041A	235745	872659	93.88	93.12	224	-125.22	-130.02	5
36MW1041B	235745	872650	93.95	93.52	155	-55.75	-60.65	5
36MW1041C	235745	872650	93.95	93.51	135	-35.85	-40.75	5
36MW1043A	237500	872399	104.58	104.23	255	-145.40	-150.19	5
36MW1043B	237499	872399	104.58	104.23	165	-55.26	-60.38	5
36PZ1001	233707	871589	33.90	33.36	7	31.90	26.90	5
36PZ1002A	234086	871664	33.74	33.46	130	-91.26	-96.26	5
36PZ1002B	234086	871664	33.74	33.62	7	31.74	26.74	5
36PZ1003	234670	871920	36.72	36.44	7	34.72	29.72	5
36PZ1010	234896	872069	49.37	51.64	30	24.37	19.37	5
36SW0003 (5)	233476	871262	N/A	N/A	N/A	N/A	N/A	N/A

Table 1
FS-1 Well Construction and Surface Water Sampling Location Information
FS-1 2009 Summary Letter Report

Location	Northing (ft)	Easting (ft)	Surface Elevation (ft msl)	Measuring Point Elevation (ft msl)	Total Well Depth (ft bgs)	Top Screen Elevation (ft msl)	Bottom Screen Elevation (ft msl)	Screen Length (ft)
36SW0010 (5)	234672	871840	N/A	N/A	N/A	N/A	N/A	N/A
36SW0019 (5)	233098	871632	N/A	N/A	N/A	N/A	N/A	N/A
36SW0036 (5)	233743	871663	N/A	N/A	N/A	N/A	N/A	N/A
36SW0200 (5)	233488	871317	N/A	N/A	N/A	N/A	N/A	N/A
36SW0303 (5)	234099	871644	N/A	N/A	N/A	N/A	N/A	N/A
36SW4188 (5)	233176	871721	N/A	N/A	N/A	N/A	N/A	N/A
36SW4200 (5)	232992	871643	N/A	N/A	N/A	N/A	N/A	N/A

Data Source: AFCEE, February 2010, MMR-AFCEE Data Warehouse

Notes:

1. The screen at 36EW0001 has a blank between -80.05 and -103.49 ft msl.
2. The effective screen length at 36EW0005 was shortened to 10 feet by installation of packers in October 2007 as part of the wellfield optimization.
3. The screen at 36EW0011 has a blank between -130.73 and -144.56 ft msl.
4. Extraction wells 36EW4020, 36EW4084, and 36EW4135 are decommissioned shallow wellpoints and are used for groundwater monitoring purposes only.
5. Locations have not been surveyed; location data is approximated.

Key:

bgs = below ground surface

ft = feet

msl = mean sea level

N/A = not applicable

Table 2
Groundwater Monitoring Results
FS-1 2009 Summary Letter Report

Location	Date	Laboratory Analyses		Field Parameters					
		EDB (µg/L) MMCL = 0.02	Pb (mg/L) Action Level = 15[2]	Temp (^{o}C)	pH (std)	DO (mg/L)	SpC (µS/cm)	ORP (mV)	Turbidity (NTU)
36EW0001	06/10/2009	0.012	NS	11.16	6.45	6.42	81	100.5	0.2
36EW0001	12/15/2009	0.017	NS	10.48	6.57	7.25	78	176.7	3.8
36EW0005	06/10/2009	**0.022**	NS	11.33	6.43	7.02	82	113.4	0.1
36EW0005	12/15/2009	**0.027**	NS	10.13	6.35	8.09	79	160.3	0.1
36EW0011	06/10/2009	**0.177**	NS	11.62	6.38	5.32	86	168	0.5
36EW0011	12/15/2009	**0.126**	NS	10.3	6.03	6.55	83	164.2	1.2
36EW4020	06/26/2009	ND	NS	--	--	--	--	--	--
36EW4084	06/25/2009	ND	NS	--	--	--	--	--	--
36EW4135	06/25/2009	ND	NS	--	--	--	--	--	--
36MW0002	6/16/2009	NS	**30.7**	15.83	5.88	1.61	66	-34.8	0.7
36MW0007	6/16/2009	NS	11.5	17.67	5.69	4.21	74	-9	0
36MW0131A	06/26/2009	BRL	NS	--	--	--	--	--	--
36MW0131B	06/26/2009	ND	NS	--	--	--	--	--	--
36MW0131C	06/26/2009	ND	NS	--	--	--	--	--	--
36MW0132A	06/25/2009	ND	NS	--	--	--	--	--	--
36MW0132B	06/25/2009	ND	NS	--	--	--	--	--	--
36MW0132C	06/25/2009	ND	NS	--	--	--	--	--	--
36MW0140	06/23/2009	ND	NS	--	--	--	--	--	--
36MW0143	06/25/2009	ND	NS	--	--	--	--	--	--
36MW0501	06/23/2009	ND	NS	--	--	--	--	--	--
36MW0504	06/23/2009	ND	NS	--	--	--	--	--	--
36MW1001A	06/23/2009	ND	NS	--	--	--	--	--	--
36MW1001B	06/23/2009	**0.048**	NS	--	--	--	--	--	--
36MW1001B	12/15/2009	0.011	NS	--	--	--	--	--	--
36MW1003A	06/26/2009	BRL	NS	--	--	--	--	--	--
36MW1010A	06/25/2009	ND	NS	--	--	--	--	--	--
36MW1010B	06/25/2009	ND	NS	--	--	--	--	--	--
36MW1010C	06/25/2009	ND	NS	--	--	--	--	--	--
36MW1011A	06/23/2009	ND	NS	--	--	--	--	--	--
36MW1011B	06/23/2009	ND	NS	--	--	--	--	--	--
36MW1012A	06/25/2009	ND	NS	--	--	--	--	--	--
36MW1012B	06/25/2009	0.016	NS	--	--	--	--	--	--
36MW1012C	06/25/2009	ND	NS	--	--	--	--	--	--
36MW1014A	06/26/2009	ND	NS	--	--	--	--	--	--
36MW1014B	06/26/2009	ND	NS	--	--	--	--	--	--
36MW1036A	06/23/2009	ND	NS	--	--	--	--	--	--
36MW1036B	06/23/2009	ND	NS	--	--	--	--	--	--
36MW1036C	06/23/2009	0.011	NS	--	--	--	--	--	--
36MW1038A	06/23/2009	ND	NS	--	--	--	--	--	--
36MW1038B	06/23/2009	ND	NS	--	--	--	--	--	--
36MW1038C	06/23/2009	ND	NS	--	--	--	--	--	--
36MW1040A	06/23/2009	**0.047**	NS	--	--	--	--	--	--
36MW1040B	06/23/2009	ND	NS	--	--	--	--	--	--
36MW1041A	06/23/2009	**0.857**	NS	--	--	--	--	--	--
36MW1041B	06/23/2009	ND	NS	--	--	--	--	--	--
36MW1041C	06/23/2009	ND	NS	--	--	--	--	--	--
36MW1043A	06/23/2009	ND	NS	--	--	--	--	--	--

Table 2
Groundwater Monitoring Results
FS-1 2009 Summary Letter Report

Location	Date	Laboratory Analyses		Field Parameters					
		EDB (µg/L) MMCL = 0.02	Pb (mg/L) Action Level = 15[2]	Temp (^{o}C)	pH (std)	DO (mg/L)	SpC (µS/cm)	ORP (mV)	Turbidity (NTU)
36MW1043B	06/23/2009	**0.028**	NS	--	--	--	--	--	--
36PZ1001	06/23/2009	ND	NS	--	--	--	--	--	--
36PZ1002A	06/25/2009	ND	NS	11.81	6.16	8.5	79	233.2	1
36PZ1002B	06/25/2009	ND	NS	--	--	--	--	--	--
36PZ1003	06/26/2009	ND	NS	--	--	--	--	--	--
36PZ1010	06/25/2009	ND	NS	13.23	5.82	0.39	109	15.8	14

Data Source: AFCEE, February 2010, MMR-AFCEE Data Warehouse

Notes :

1. MMCL from Massachusetts Department of Environmental Protection (MassDEP) web page, http://www.mass.gov/dep/water/dwstand.pdf.
2. Value reported is the treatment technique action level for lead in drinking water systems from U.S. Environmental Protection Agency (EPA) web page, http://www.epa.gov/safewater/consumer/pdf/mcl.pdf.

Bold values represent EDB concentrations above the MMCL .

--: Sample collected through use of passive diffusion bag sampler; field parameter collection not performed.

Key:

BRL = below the reporting limit
°C = degrees Celsius
DO = dissolved oxygen
EDB = ethylene dibromide
mg/L = milligrams per liter
MMCL = Massachusetts Maximum Contaminant Level
mV = millivolts
ND = not detected
NTU = nephelometric turbidity units
ORP = oxidation-reduction potential
Pb = lead
SpC = specific conductance
std = standard units
Temp = temperature
µg/L = micrograms per liter
µS/cm = microsiemens per centimeter

Table 3
Surface Water Monitoring Results
FS-1 2009 Summary Letter Report

Location Identification	Date	Laboratory Analyses	Field Parameters					
		EDB [1,2] (µg/L)	Temp (°C)	DO (mg/L)	pH (std)	SpC (µS/cm)	ORP (mV)	Turbidity (NTU)
36SW0003	05/19/2009	ND	16.34	11.77	6.74	107	94.50	0.50
36SW0003	07/07/2009	ND	16.20	9	6.21	115	152.40	0.80
36SW0003	09/08/2009	ND	15.90	12.19	6.82	86	140.10	0.50
36SW0010	09/08/2009	ND	11.68	10.75	6.30	67	168.20	7.50
36SW0019	05/19/2009	ND	12.52	0.50	6.67	86	29.80	80.80
36SW0019	07/07/2009	BRL	15.03	6.82	6.38	91	26.00	3.10
36SW0019	09/08/2009	0.023	15.50	7.87	6.99	89	153.70	1.90
36SW0036	09/08/2009	ND	17.58	5.75	6.66	53	78.70	21.10
36SW0200	09/08/2009	ND	17.47	10.89	6.93	93	128.40	4.20
36SW0303	09/08/2009	ND	14.70	6.49	6.39	68	129.50	7.80
36SW4188	09/08/2009	ND	16.54	7.63	7.03	113	67.10	14.30
36SW4200	05/19/2009	ND	12.19	0.27	6.71	77	19.50	45.80
36SW4200	05/19/2009	ND	12.19	0.27	6.71	77	19.50	45.80
36SW4200	07/07/2009	ND	21.85	7.27	6.48	83	66.40	4.40
36SW4200	09/08/2009	0.011	16.73	11.79	7.14	86	150.10	6.30

Data Source: AFCEE, February 2010, MMR-AFCEE Data Warehouse

Notes:

1. EDB screening-level risk based concentration for imminent human health risk (10^{-3} risk) = 6.5 µg/L: *Preliminary Screening-Level Human Health Risk Evaluation for Fuel Spill-1 Surface Water and Treatment System Data* ; Appendix D of *Final Fuel Spill-1 2002 Annual System Performance and Ecological Impact Monitoring Report* , dated May 2003.

2. EDB screening-level ecological benchmark for surface water = 31 µg/L: *Final Ethylene Dibromide Derivation of Aquatic Screening Benchmarks,* dated November 1998.

Key:

°C = degrees Celsius
DO = dissolved oxygen
EDB = ethylene dibromide
mg/L = milligrams per liter
mV = millivolts
ND = not detected
NTU = nephelometric turbidity units
ORP = oxidation-reduction potential
SpC = specific conductance
std = standard units
Temp = temperature
µg/L = micrograms per liter
µS/cm = microsiemens per centimeter

Table 4
FS-1 Meeting Presentations
FS-1 2009 Summary Letter Report

Technical Update Meetings

11 February 2009	FS-1 2008 Semiannual SPEIM Data Presentation
08 April 2009	FS-1 2008 Semiannual SPEIM Data Presentation Follow-up
16 September 2009	FS-1 Cyclic Pumping Project Note

MMR Cleanup Team (MMRCT)

No presentations

SMB Meetings

No presentations

Conferences

No presentations

Table 5
FS-1 Treatment Plant Sampling Results
FS-1 2009 Summary Letter Report

Month of Event	Sample Date	Location Identification	Sample Location	Laboratory Analyses	Field Parameters					
				EDB (µg/L) MMCL = 0.02	Temp (°C)	SpC (µS/cm)	DO (mg/L)	pH (std)	ORP (mV)	Turbidity (NTU)
February	26-Jan-09	36PLT02001	Combined Influent	**0.100**	--	--	--	--	--	--
		36PLT02004	Post GAC 103	**0.058**	--	--	--	--	--	--
		36PLT02002	Post GAC 101	BRL	--	--	--	--	--	--
		36PLT02005	Plant Effluent	ND	--	--	--	--	--	--
March	23-Feb-09	36PLT02001	Combined Influent	**0.101**	--	--	--	--	--	--
		36PLT02004	Post GAC 103	**0.066**	--	--	--	--	--	--
		36PLT02002	Post GAC 101	0.010	--	--	--	--	--	--
		36PLT02005	Plant Effluent	ND	--	--	--	--	--	--
April	25-Mar-09	36PLT02001	Combined Influent	**0.098**	--	--	--	--	--	--
		36PLT02004	Post GAC 103	**0.068**	--	--	--	--	--	--
		36PLT02002	Post GAC 101	0.015	--	--	--	--	--	--
		36PLT02005	Plant Effluent	ND	--	--	--	--	--	--
Carbon was exchanged in CF102 on 16 April 2009. Following the exchange, CF101 became the lead GAC vessel, CF102 became the lag vessel and CF103 became the polishing vessel.										
May	24-Apr-09	36PLT02001	Combined Influent	**0.094**	--	--	--	--	--	--
		36PLT02002	Post GAC 101	ND	--	--	--	--	--	--
		36PLT02003	Post GAC 102	ND	--	--	--	--	--	--
		36PLT02005	Plant Effluent	ND	--	--	--	--	--	--
A resample was collected from 36PLT02002 after the initial result was returned from the laboratory as a non-detect.										
Resample	29-Apr-09	36PLT02002	Post GAC 101	**0.023**	--	--	--	--	--	--
June	26-May-09	36PLT02001	Combined Influent	**0.092**	10.28	83	6.11	6.30	160.3	0.0
		36PLT02002	Post GAC 101	**0.033**	10.30	82	5.74	6.25	173.5	0.0
		36PLT02003	Post GAC 102	BRL	10.31	82	6.26	6.19	191.4	0.0
		36PLT02005	Plant Effluent	ND	10.32	82	4.76	6.13	177.1	0.0
July	24-Jun-09	36PLT02001	Combined Influent	**0.091**	--	--	--	--	--	--
		36PLT02002	Post GAC 101	**0.043**	--	--	--	--	--	--
		36PLT02003	Post GAC 102	ND	--	--	--	--	--	--
		36PLT02005	Plant Effluent	ND	--	--	--	--	--	--
August	27-Jul-09	36PLT02001	Combined Influent	**0.085**	--	--	--	--	--	--
		36PLT02002	Post GAC 101	**0.044**	--	--	--	--	--	--
		36PLT02003	Post GAC 102	ND	--	--	--	--	--	--
		36PLT02005	Plant Effluent	ND	--	--	--	--	--	--

Table 5
FS-1 Treatment Plant Sampling Results
FS-1 2009 Summary Letter Report

Month of Event	Sample Date	Location Identification	Sample Location	Laboratory Analyses	Field Parameters					
				EDB (µg/L) MMCL = 0.02	Temp (°C)	SpC (µS/cm)	DO (mg/L)	pH (std)	ORP (mV)	Turbidity (NTU)
September	28-Aug-09	36PLT02001	Combined Influent	**0.093**	--	--	--	--	--	--
		36PLT02002	Post GAC 101	**0.054**	--	--	--	--	--	--
		36PLT02003	Post GAC 102	0.011	--	--	--	--	--	--
		36PLT02005	Plant Effluent	ND	--	--	--	--	--	--
October	25-Sep-09	36PLT02001	Combined Influent	**0.089**	--	--	--	--	--	--
		36PLT02002	Post GAC 101	**0.056**	--	--	--	--	--	--
		36PLT02003	Post GAC 102	0.019	--	--	--	--	--	--
		36PLT02005	Plant Effluent	ND	--	--	--	--	--	--
Carbon was exchanged in CF101 on 12 October 2009. Following the exchange, CF102 became the lead GAC vessel, CF103 became the lag vessel and CF1012 became the polishing vessel.										
November	26-Oct-09	36PLT02001	Combined Influent	**0.093**	--	--	--	--	--	--
		36PLT02003	Post GAC 102	**0.027**	--	--	--	--	--	--
		36PLT02004	Post GAC 103	ND	--	--	--	--	--	--
		36PLT02005	Plant Effluent	ND	--	--	--	--	--	--
December	24-Nov-09	36PLT02001	Combined Influent	**0.072**	10.04	85	6.20	6.07	64.2	0.0
		36PLT02003	Post GAC 102	**0.044**	10.04	85	5.91	6.06	64.3	0.0
		36PLT02004	Post GAC 103	BRL	10.05	85	5.24	6.05	62.3	0.0
		36PLT02005	Plant Effluent	ND	10.05	85	4.77	6.05	59.3	0.0
January	28-Dec-09	36PLT02001	Combined Influent	**0.077**	--	--	--	--	--	--
		36PLT02003	Post GAC 102	**0.035**	--	--	--	--	--	--
		36PLT02004	Post Gac 103	BRL	--	--	--	--	--	--
		36PLT02005	Plant Effluent	ND	--	--	--	--	--	--

Data Source: AFCEE, March 2010, MMR-AFCEE Data Warehouse

Notes:

Bold values represent EDB concentration above MMCL.

Field parameters (pH, temperature, dissolved oxygen, conductivity, turbidity and oxidation/reduction potential) are measured semiannually at influent, post-GAC at each active GAC vessel, and plant effluent sampling locations. The measurements are taken using a flow-thru cell and the Yellow Springs Instrument (YSI).

Key:

BRL = below reporting limit
°C = degrees Celsius
DO = dissolved oxygen
EDB = ethylene dibromide
GAC = granular activated carbon
mg/L = milligrams per liter (parts per million)
MMCL = Massachusetts Maximum Contaminant Level
mV = millivolts
ND = not detected
NTU = nephelometric turbidity units
ORP = oxidation-reduction potential
SpC = specific conductance
Temp = temperature
µg/L = micrograms per liter (parts per billion)
µS/cm = microseimens per centimeter

Table 6
FS-1 Treatment System Flow Rates
FS-1 2009 Summary Letter Report

Week Ending	36EW0001 Flow Rate (gpm)	36EW0005 Flow Rate (gpm)	36EW0011 Flow Rate (gpm)	Treatment Plant Total Flow (gpm)
2007 Scenario 01				
7-Jan-09	90	175	250	515
14-Jan-09	90	175	250	515
21-Jan-09	90	175	250	515
28-Jan-09	90	175	250	515
4-Feb-09	90	175	250	515
11-Feb-09	90	175	250	515
18-Feb-09	90	175	250	515
25-Feb-09	90	175	250	515
4-Mar-09	81	158	226	466
11-Mar-09	90	175	250	515
18-Mar-09	90	175	250	515
25-Mar-09	90	175	250	515
1-Apr-09	90	175	250	515
8-Apr-09	90	175	250	515
15-Apr-09	90	175	250	515
22-Apr-09	90	175	249	514
29-Apr-09	90	173	250	513
6-May-09	89	175	250	514
13-May-09	89	175	250	514
20-May-09	89	175	250	514
27-May-09	89	175	250	514
3-Jun-09	61	118	169	348
10-Jun-09	90	175	250	515
17-Jun-09	87	168	241	495
24-Jun-09	90	175	250	515
1-Jul-09	90	175	250	515
8-Jul-09	90	175	250	515
15-Jul-09	90	175	250	515
22-Jul-09	90	175	250	515
29-Jul-09	90	175	250	515
5-Aug-09	90	175	250	515
12-Aug-09	90	175	250	515
19-Aug-09	90	175	250	515
26-Aug-09	90	175	250	515
2-Sep-09	90	175	250	515
9-Sep-09	46	90	128	265
16-Sep-09	90	174	249	512
23-Sep-09	89	173	247	508
30-Sep-09	90	175	250	515
7-Oct-09	83	162	231	477
14-Oct-09	82	165	229	477
21-Oct-09	90	176	250	516
28-Oct-09	90	175	250	515
4-Nov-09	90	174	250	514
11-Nov-09	89	175	248	512
18-Nov-09	90	175	250	515
25-Nov-09	90	175	249	514
2-Dec-09	90	175	250	515
9-Dec-09	90	175	250	515

Table 6
FS-1 Treatment System Flow Rates
FS-1 2009 Summary Letter Report

Week Ending	36EW0001 Flow Rate (gpm)	36EW0005 Flow Rate (gpm)	36EW0011 Flow Rate (gpm)	Treatment Plant Total Flow (gpm)
16-Dec-09	90	175	250	515
23-Dec-09	71	139	199	409
30-Dec-09	90	175	250	515
Average Flow Rate (gpm)	**88**	**171**	**244**	**502**
Optimized Design Flow Rate (gpm) (2007 Scenario 01)	**90**	**175**	**250**	**515**
Percent of Optimized Design Rate	**97**	**97**	**97**	**97**

Data Source: AFCEE, February 2010, MMR-AFCEE Data Warehouse.

Notes:

36EW0007 taken offline on 01 October 2007.

Flow rates presented are weekly averages.

Any downtimes due to routine and non-routine operations and maintenance activities were included in the average flow rates.

Key:

gpm = gallons per minute

Table 7
Treatment System Downtime Summary
FS-1 2009 Summary Letter Report

Date	Hours Off-Line	Reason
3/1/2009	9.52	System tripped off due to power loss from inclement weather.
5/30/2009	41.55	System off due to a power failure.
6/14/2009	6.25	System off due to a power failure.
9/5/2009	81.33	Plant tripped due to a bad relay in Programmable Logic Control cabinet.
9/21/2009	2.33	Plant shut down for energy reduction event (Demand Response Program
10/6/2009	11.97	System off due to a power failure.
10/12/2009	13.97	Loose wire on 24-Volt converter. No power to fiber modem. No communications to wells.
11/4/2009	2.25	36EW0005 off for pump test.
11/10/2009	2.55	36EW0001 off for pump test.
11/10/2009	2.08	36EW0011 off for pump test.
12/20/2009	22.25	Plant tripped due to a power failure caused by a snow storm.

Table 8
FS-1 Treatment System Mass Removal Summary
FS-1 2009 Summary Letter Report

Date	36EW0001		36EW0005		36EW0007[3]		36EW0011		Total EDB Removed (Extraction Well Sampling)		Total EDB Removed (Plant Influent Sampling)	
	Incremental Mass Removed (lbs)	Cumulative Mass Removed (lbs)	Incremental Mass Removed (lbs)	Cumulative Mass Removed (lbs)	Incremental Mass Removed (lbs)	Cumulative Mass Removed (lbs)	Incremental Mass Removed (lbs)	Cumulative Mass Removed (lbs)	Incremental Mass Removed (lbs)	Cumulative Mass Removed (lbs)	Incremental Mass Removed (lbs)	Cumulative Mass Removed (lbs)
Jan-09	0.001	0.791	0.002	1.362	0.000	1.095	0.015	3.553	0.017	6.801	0.020	7.113
Feb-09	0.000	0.792	0.001	1.364	0.000	1.095	0.014	3.567	0.016	6.818	0.017	7.131
Mar-09	0.000	0.792	0.002	1.365	0.000	1.095	0.015	3.582	0.017	6.834	0.019	7.149
Apr-09	0.000	0.793	0.001	1.367	0.000	1.095	0.015	3.597	0.017	6.852	0.018	7.167
May-09	0.000	0.793	0.001	1.368	0.000	1.095	0.015	3.612	0.017	6.868	0.017	7.183
Jun-09	0.000	0.793	0.001	1.370	0.000	1.095	0.015	3.628	0.017	6.886	0.017	7.200
Jul-09	0.000	0.794	0.001	1.371	0.000	1.095	0.016	3.643	0.017	6.903	0.017	7.217
Aug-09	0.000	0.794	0.002	1.373	0.000	1.095	0.015	3.658	0.017	6.920	0.017	7.234
Sep-09	0.000	0.795	0.001	1.374	0.000	1.095	0.012	3.670	0.014	6.934	0.015	7.249
Oct-09	0.000	0.795	0.002	1.376	0.000	1.095	0.013	3.683	0.015	6.949	0.017	7.266
Nov-09	0.001	0.796	0.002	1.377	0.000	1.095	0.012	3.695	0.014	6.963	0.015	7.280
Dec-09	0.001	0.796	0.002	1.379	0.000	1.095	0.011	3.706	0.013	6.976	0.014	7.294
EDB Removed (lbs) by Final ETD System (January 2009 - December 2009)						**0.20**						
EDB Removed (lbs) by Final ETD System since startup (September 2003 - December 2009) [1]						**7.29**						
EDB Removed (lbs) by Interim ETD System (April 1999 - October 2002) [2]						**10.31**						
Total EDB Mass Removed (lbs) between April 1999 and December 2009						**17.61**						

Data Source: AFCEE, February 2010, MMR-AFCEE Data Warehouse

Notes:

1. Final ETD system began operation on 30 September 2003.
2. Interim ETD system operated between April 1999 and October 2002.
3. 36EW0007 was turned off on 01 October 2007 as part of the ETD system optimization.

Key:

ETD = extraction, treatment, and discharge

EDB = ethylene dibromide

lbs = pounds

Table 9
FS-1 Remedial Systems Electrical Consumption and Associated Air Emissions
FS-1 2009 Summary Letter Report

		1/1/2009 to 12/31/2009	System Startup (4/1999) to 12/31/2009 [4]
Volume of Groundwater Treated (million gallons)		**264**	**3,305**
Groundwater COC Mass Removal (pounds)		**0.20**	**17.61**
Electrical Usage (MWh)		**259**	**3,994**
Estimated Air Emissions[1] (based on electrical usage)	**CO_2**	188	2,651
	NOx	352	5,603
	PM-10	17	315
	SO_2	709	14,505
	VOCs	14	199
Estimated Reduction in Air Emissions due to Green Power Purchases[2]	**CO_2**	94	230
	NOx	176	380
	PM-10	8	15
	SO_2	355	520
	VOCs	7	16
Estimated Reduction in Air Emissions due to MMR Wind Turbine Operation[3]	**CO_2**	3	3
	NOx	7	7
	PM-10	0.4	0.4
	SO_2	18	18
	VOCs	0.2	0.2
Estimated Total Air Emissions with consideration of Green Power Purchases and MMR Wind Turbine Operation	**CO_2**	**91**	**2,418**
	NOx	**169**	**5,216**
	PM-10	**8**	**300**
	SO_2	**337**	**13,967**
	VOCs	**7**	**182**

Notes:

1) The estimated air emissions presented in this table are based on the assumption that until 4/30/2009, the power used to operate the MMR remedial systems was provided by the Canal Power Plant in Sandwich, MA. This power plant primarily produced electricity generated by the combustion of fuel oil and has been off-line since 5/1/2009. Starting on 5/1/2009, air emissions are based on electricity generated by the average mix of power sources in Massachusetts. Air emissions were calculated using MMR utility data from AFCEE's Metrix 4 Utility Accounting Software (http://www.abraxasenergy.com/metrix4.php) and emission factors obtained from the following websites:
http://www.csgnetwork.com/elecpowerpolcalc.html
http://www.metrixcentral.com/EmissionsCalculator/Emissions%20Factors%202004.pdf
2) Emissions offset by purchases of electricity from renewable sources beginning 7/1/2008.
3) Emissions offset by operation of AFCEE-owned wind turbine beginning on 12/2/2009.
4) System was not operational between October 2002 and September 2003, system was down due to a fire that consumed the original plant.

Key:
COC = contaminant of concern
CO_2 = carbon dioxide reported in tons
FS-1 = Fuel Spill-1
MMR = Massachusetts Military Reservation
MWh = megawatt hours
NO_x = nitrogen oxides reported in pounds
PM-10 = particulate matter with a diameter of 10 micrometers or less reported in pounds
SO_2 = sulfur dioxide reported in pounds
VOCs = volatile organic compounds reported in pounds

ATTACHMENT A

Comparison of Detected Concentrations in FS-1 Groundwater, Surface Water, and Treatment Plant Samples to Applicable Groundwater and Surface Water Standards

Attachment A

Comparison of Detected Concentrations in FS-1 Groundwater, Surface Water, and Treatment Plant Samples to Applicable Groundwater and Surface Water Standards

FS-1 2009 Summary Letter Report

Location	Date	Sample Elevation (ft msl)	Matrix	Test	Analyte	Result	DL	RL	Standard	Type [1,2,3,4]	Standard Exceeded?
						All Units = µg/L					
36EW0001	6/10/2009	-67.30	WG	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.012	0.003	0.01	0.02	MMCL	No
36EW0001	12/15/2009	-67.30	WG	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.017	0.003	0.01	0.02	MMCL	No
36EW0005	6/10/2009	-115.24	WG	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.022	0.003	0.01	0.02	MMCL	Yes
36EW0005	12/15/2009	-115.24	WG	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.027	0.003	0.01	0.02	MMCL	Yes
36EW0011	6/10/2009	-119.64	WG	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.177	0.003	0.01	0.02	MMCL	Yes
36EW0011	12/15/2009	-119.64	WG	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.126	0.003	0.01	0.02	MMCL	Yes
36MW0002	6/16/2009	54.29	WG	SW6020	LEAD	30.7	0.026	0.5	15	Action Level[4]	Yes
36MW0007	6/16/2009	56.20	WG	SW6020	LEAD	11.5	0.026	0.5	15	Action Level[4]	No
36MW0131A	6/26/2009	-130.35	WG	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	BRL	0.003	0.01	0.02	MMCL	No
36MW1001B	6/23/2009	-62.87	WG	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.048	0.003	0.01	0.02	MMCL	Yes
36MW1001B	12/15/2009	-62.87	WG	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.011	0.003	0.01	0.02	MMCL	No
36MW1003A	6/26/2009	-115.11	WG	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	BRL	0.003	0.01	0.02	MMCL	No
36MW1012B	6/25/2009	-37.30	WG	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.016	0.003	0.01	0.02	MMCL	No
36MW1036C	6/23/2009	-64.66	WG	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.011	0.003	0.01	0.02	MMCL	No
36MW1040A	6/23/2009	-151.58	WG	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.047	0.003	0.01	0.02	MMCL	Yes
36MW1041A	6/23/2009	-127.62	WG	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.857	0.003	0.01	0.02	MMCL	Yes
36MW1043B	6/23/2009	-57.82	WG	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.028	0.003	0.01	0.02	MMCL	Yes
36PLT02001 (INF)	1/26/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.1	0.002	0.01	0.02	MMCL	Yes
36PLT02001 (INF)	2/23/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.101	0.002	0.01	0.02	MMCL	Yes
36PLT02001 (INF)	3/25/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.098	0.002	0.01	0.02	MMCL	Yes
36PLT02001 (INF)	4/24/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.094	0.002	0.01	0.02	MMCL	Yes
36PLT02001 (INF)	5/26/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.092	0.002	0.01	0.02	MMCL	Yes
36PLT02001 (INF)	6/24/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.091	0.003	0.01	0.02	MMCL	Yes
36PLT02001 (INF)	7/27/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.085	0.003	0.01	0.02	MMCL	Yes
36PLT02001 (INF)	8/28/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.093	0.003	0.01	0.02	MMCL	Yes
36PLT02001 (INF)	9/25/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.089	0.003	0.01	0.02	MMCL	Yes
36PLT02001 (INF)	10/26/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.093	0.003	0.01	0.02	MMCL	Yes
36PLT02001 (INF)	11/24/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.072	0.003	0.01	0.02	MMCL	Yes
36PLT02001 (INF)	12/28/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.077	0.003	0.01	0.02	MMCL	Yes
36PLT02002 (MID)	1/26/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	BRL	0.002	0.01	0.02	MMCL	No
36PLT02002 (MID)	2/23/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.01	0.002	0.01	0.02	MMCL	No
36PLT02002 (MID)	3/25/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.015	0.002	0.01	0.02	MMCL	No
36PLT02002 (MID)	4/29/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.023	0.002	0.01	0.02	MMCL	Yes
36PLT02002 (MID)	5/26/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.033	0.002	0.01	0.02	MMCL	Yes
36PLT02002 (MID)	6/24/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.043	0.003	0.01	0.02	MMCL	Yes
36PLT02002 (MID)	7/27/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.044	0.003	0.01	0.02	MMCL	Yes

Attachment A

Comparison of Detected Concentrations in FS-1 Groundwater, Surface Water, and Treatment Plant Samples to Applicable Groundwater and Surface Water Standards

FS-1 2009 Summary Letter Report

Location	Date	Sample Elevation (ft msl)	Matrix	Test	Analyte	Result	DL	RL	Standard	Type [1,2,3,4]	Standard Exceeded?
						All Units = µg/L					
36PLT02002 (MID)	8/28/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.054	0.003	0.01	0.02	MMCL	Yes
36PLT02002 (MID)	9/25/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.056	0.003	0.01	0.02	MMCL	Yes
36PLT02003 (MID)	5/26/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	BRL	0.002	0.01	0.02	MMCL	No
36PLT02003 (MID)	8/28/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.011	0.003	0.01	0.02	MMCL	No
36PLT02003 (MID)	9/25/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.019	0.003	0.01	0.02	MMCL	No
36PLT02003 (MID)	10/26/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.027	0.003	0.01	0.02	MMCL	Yes
36PLT02003 (MID)	11/24/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.044	0.003	0.01	0.02	MMCL	Yes
36PLT02003 (MID)	12/28/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.035	0.003	0.01	0.02	MMCL	Yes
36PLT02004 (MID)	1/26/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.058	0.002	0.01	0.02	MMCL	Yes
36PLT02004 (MID)	2/23/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.066	0.002	0.01	0.02	MMCL	Yes
36PLT02004 (MID)	3/25/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.068	0.002	0.01	0.02	MMCL	Yes
36PLT02004 (MID)	11/24/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	BRL	0.003	0.01	0.02	MMCL	No
36PLT02004 (MID)	12/28/2009	N/A	WW	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	BRL	0.003	0.01	0.02	MMCL	No
36SW0019	7/7/2009	N/A	WS	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	BRL	0.003	0.01	$6.5^{(2)}/31^{(3)}$	RBC/ECO	No
36SW0019	9/8/2009	N/A	WS	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.023	0.003	0.01	$6.5^{(2)}/31^{(3)}$	RBC/ECO	No
36SW4200	9/8/2009	N/A	WS	E504.1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	0.011	0.003	0.01	$6.5^{(2)}/31^{(3)}$	RBC/ECO	No

Data Source: AFCEE, February 2010, MMR-AFCEE Data Warehouse

Notes:

1. MMCL from Massachusetts Department of Environmental Protection (MassDEP) web page, http://www.mass.gov/dep/water/dwstand.pdf.

2. EDB screening-level risk based concentration for imminent human health risk (10^{-3} risk) = 6.5 µg/L: *Preliminary Screening-Level Human Health Risk Evaluation for Fuel Spill-1 Surface Water and Treatment System Data* ; Appendix D of *Final Fuel Spill-1 2002 Annual System Performance and Ecological Impact Monitoring Report* , dated May 2003.

3. EDB screening-level ecological benchmark for surface water: *Final Ethylene Dibromide Derivation of Aquatic Screening Benchmarks* , dated November 1998.

4. Value reported is the treatment technique action level for lead in drinking water systems from Environmental Protection Agency (EPA) web page, http://www.epa.gov/safewater/consumer/pdf/mcl.pdf.

Key:

BRL = below reporting limit
DL = detection limit
ECO = screening-level ecological benchmark
EDB = ethylene dibromide
ft msl = feet mean sea level
INF = treatment plant influent
MID = treatment plant midpoint sample
MMCL = Massachusetts Maximum Contaminant Level
N/A = information not applicable
RBC = human health screening-level risk based concentration (risk = 10^{-3})
RL = reporting limit
TT = treatment technique
WG = groundwater sample
WS = surface water sample
WW = plant water sample
µg/L = micrograms per liter

ATTACHMENT B

FS-1 2009 SLR
Data Summary Reports

ATTACHMENT B-1
Data Summary Report for Data Collected Under AFCEE 4P08 Task Orders
(January 2009 through December 2009)

ATTACHMENT B-2
Data Summary Report for Data Collected Under AFCEE ECOS Task Order
(June 2009 through December 2009)

ATTACHMENT B-1

Data Summary Report for Data Collected Under AFCEE 4P08 Task Orders (January 2009 through December 2009)

Attachment B-1
Data Summary Report
Fuel Spill-1 2009 Summary Letter Report

INTRODUCTION

The objective of this data summary report (DSR) is to assess the data quality of analytical results for samples collected for the Fuel Spill-1 System Performance and Ecological Impact Monitoring (SPEIM) Program at the Massachusetts Military Reservation (MMR) as presented in the *Fuel Spill-1 2009 Summary Letter Report*. This report is intended as a general data quality assessment designed to summarize data issues.

ANALYTICAL DATA

This DSR covers three surfacewater samples with one field duplicate samples, and 21 plant samples. Field duplicates are not required for treatment facility plant samples. These samples were reported under seven sample delivery groups. Samples were collected between 26 January 2009 and 26 May 2009. The analyses were performed by Groundwater Analytical Laboratory (GWAM) at MMR. Samples were collected and hand-delivered to GWAM; for analysis. Samples were analyzed for the analyte/method provided in Table B1-1.

Table B1-1
Analytical Parameter

Parameter	Method	Laboratory
Ethylene Dibromide	E504.1	GWAM

E = Environmental Protection Agency (EPA) Method

The data were assessed using the MMR SPEIM Quality Assurance Project Plan (QAPP)[1]. The assessment included a review of the following:

- Chain-of-Custody documentation
- Holding time compliance

[1] AFCEE. 2009 (December). *Quality Assurance Project Plan for the MMR SPEIM/LTM/O&M Program*. 389849-Program-Multiple-QAPP-001. Prepared by CH2M HILL for AFCEE/MMR Installation Restoration Program, Otis Air National Guard Base, MA.

- Required quality control (QC) samples at the specified frequencies
- Method blanks
- Laboratory control spiking samples
- Surrogate spike recoveries
- Initial and continuing calibration information and other method-specific criteria as defined by the SPEIM QAPP

Field samples were reviewed to ascertain field compliance and data quality issues. This included a review of an equipment blank and field duplicate.

Definitive data generated prior to July 2004, were carried through a Tier II data validation as defined by the SPEIM QAPP. In July 2004, an automated validation approach as described in the SPEIM QAPP was implemented for samples analyzed using method E504.1 received from GWAM, the onsite laboratory at MMR. When using the automated approach, the Validation Data Management System software automatically imported, validated, and created an exceedance report that was reviewed by the project chemist. The automated system reviewed all the same QC elements as the semi-automated review process with the exception of initial and continuing calibration criteria. The same flagging criteria were used for both processes.

To provide additional confidence in the automated process for this method, data were compared to historical results, as described in the SPEIM QAPP. They were reviewed for outlying quantitative data that might suggest a data quality issue that could affect data usability. This report was also reviewed by the project chemist. When new data appeared to be inconsistent with historical data, the automated process was superceded by manually performing a Tier II validation to resolve the identified inconsistencies. Sample locations that had insufficient historical data were validated using the Tier II process defined in the SPEIM QAPP until sufficient data were collected to allow use of the automated system (minimum of three data points).

Data flags were assigned according to the SPEIM QAPP. These flags, and the reason for each flag, were entered into the electronic database. Multiple flags are routinely applied

to specific sample method/matrix/analyte combinations, but there is only one final flag. A final flag is applied to the data, and is the most conservative of the applied validation flags. The final flag also includes matrix and blank sample impacts.

The data flags are listed in the SPEIM QAPP and are defined as follows:

- J = Analyte was present but the reported value may not be accurate or precise (estimated).
- R = Analyte result was unusable due to deficiencies in the ability to analyze the sample and meet QC criteria.
- U = Analyte was not detected at the specified detection limit.
- UJ = Analyte was not detected and the specified detection limit may not be accurate or precise (estimated).

FINDINGS

The summaries of the data validation findings are contained in the following subsections.

Holding Times

All holding time criteria were met.

Calibration

Initial and continuing calibrations were analyzed as required in every analytical batch and were in control for the Tier II validated data. No calibration flags were applied.

Method Blanks

Method blanks were analyzed at the required frequency for each method. No method blank flags were applied.

Field Blanks

One equipment blank was collected and analyzed at the required frequency. No field blank flags were applied.

Field Duplicates

One field duplicate was collected as required, and precision was acceptable. No field duplicate flags were applied.

Matrix Spike Samples

Matrix spike/matrix spike duplicates were not required for routine sample locations.[2]

Surrogates

Surrogate recoveries met each method SPEIM QAPP criteria overall. No surrogate flags were applied.

Laboratory Control Samples

Laboratory control sample/laboratory control sample duplicates (LCS/LCSD) were analyzed as required and in control. No LCS flags were applied.

Confirmation Results

Confirmation samples were analyzed as required by method E504.1. No confirmation flags were applied.

Chain of Custody

No chain of custody anomalies were noted in the review.

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[2] AFCEE. 2004 (October). Project Note: *SPEIM and LTM Monitoring Reduction in FD and MS/MSD Sampling*. 187815-SPEIM-Multiple-PRJNOT-003. Prepared by CH2M HILL for AFCEE/MMR Installation Restoration Program, Otis Air National Guard Base, MA.

Overall Assessment

The goal of this assessment is to demonstrate that a sufficient number of representative samples were collected and the resulting analytical data can be used to support the decision-making process. The procedures for assessing the precision, accuracy, representativeness, completeness, and comparability parameters (PARCC) are addressed in the SPEIM QAPP. The following summary highlights the PARCC findings for the above-defined events:

1. The completeness goal for valid usable data is 95 percent for aqueous samples. Completeness for aqueous samples was 100 percent.

2. The routinely acceptable performance of field and laboratory QC indicators (field duplicates, field blanks, laboratory blanks, surrogate spikes, LCS/LCSD, and calibrations) shows that the precision and accuracy of the data met project objectives.

3. Sample results are representative and comparable to field conditions and past historical data because the field sampling and laboratory analyses were performed using standardized and documented procedures as defined in project documents. In addition, all results were reported with industry standard units. No sample results were qualified due to blank contamination.

Attachment B-1
Analytical Laboratory Results, January - May 2009
Fuel Spill-1 2009 Summary Letter Report

Location	Sample ID	Date	Test	Type	Analyte	Matrix	Depth	Analyte Result	DL	RL	Units	Qual
36PLT02001	CHTD02001-M0209	1/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.1	0.002	0.01	µg/L	
36PLT02001	CHTD02001-M0309	2/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.101	0.002	0.01	µg/L	
36PLT02001	CHTD02001-M0409	3/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.098	0.002	0.01	µg/L	
36PLT02001	CHTD02001-M0509	4/24/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.094	0.002	0.01	µg/L	
36PLT02001	CHTD02001-M0609	5/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.092	0.002	0.01	µg/L	
36PLT02002	CHTD02002-M0209	1/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		BRL	0.002	0.01	µg/L	J
36PLT02002	CHTD02002-M0309	2/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.01	0.002	0.01	µg/L	
36PLT02002	CHTD02002-M0409	3/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.015	0.002	0.01	µg/L	
36PLT02002	CHTD02002-R0509	4/29/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.023	0.002	0.01	µg/L	
36PLT02002	CHTD02002-M0609	5/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.033	0.002	0.01	µg/L	
36PLT02003	CHTD02003-M0509	4/24/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.002	0.01	µg/L	U
36PLT02003	CHTD02003-M0609	5/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		BRL	0.002	0.01	µg/L	J
36PLT02004	CHTD02004-M0209	1/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.058	0.002	0.01	µg/L	
36PLT02004	CHTD02004-M0309	2/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.066	0.002	0.01	µg/L	
36PLT02004	CHTD02004-M0409	3/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.068	0.002	0.01	µg/L	
36PLT02005	CHTD02005-M0209	1/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.002	0.01	µg/L	U
36PLT02005	CHTD02005-M0309	2/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.002	0.01	µg/L	U
36PLT02005	CHTD02005-M0409	3/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.002	0.01	µg/L	U
36PLT02005	CHTD02005-M0509	4/24/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.002	0.01	µg/L	U
36PLT02005	CHTD02005-M0609	5/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.002	0.01	µg/L	U
36SW0003	CHPN08003-M0509	5/19/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WS		ND	0.002	0.01	µg/L	U
36SW0019	CHPN08019-M0509	5/19/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WS		ND	0.002	0.01	µg/L	U
36SW4200	CHPN08420-M0509	5/19/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WS		ND	0.002	0.01	µg/L	U
36SW4200	CHPN18420-M0509	5/19/2009	E504.1	FD1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WS		ND	0.002	0.01	µg/L	U

Data Source: AFCEE, January 2010, MMR-AFCEE Data Warehouse

Key:

BRL = below reporting limit
DL = detection limit
FD1 = field duplicate
J = estimated value
ND = nondetect
N1 = native sample
RL = reporting limit
U = undetected
WS = surface water
WW = wastewater
µg/L = micrograms per liter

ATTACHMENT B-2

Data Summary Report for Data Collected Under AFCEE ECOS Task Order (June 2009 through December 2009)

Attachment B-2
Data Summary Report
Fuel Spill-1 2009 Summary Letter Report

INTRODUCTION

The objective of this data summary report (DSR) is to assess the data quality of analytical results for samples collected from the Fuel Spill-1 (FS-1) Source Area under the System Performance and Ecological Impact Monitoring (SPEIM) Program at the Massachusetts Military Reservation (MMR), as presented in the *Fuel Spill-1 2009 Summary Letter Report*. This report is intended as a general data quality assessment designed to summarize data issues.

ANALYTICAL DATA

This DSR covers 53 groundwater samples with one field duplicate sample, 11 surface water samples, and 28 plant samples. Field duplicates are not required for plant samples from the treatment facility. These samples were reported under 15 sample delivery groups (SDGs). The samples were collected between 10 June 2009 and 28 December 2009. The analyses were performed by Alpha Analytical Laboratories (Alpha), Westborough, Massachusetts. All samples were collected and shipped same-day via Alpha courier for analysis. The samples were analyzed for one or more of the analytes/methods provided in Table B2-1.

Table B2-1
Analytical Parameter

Parameter	Method	Laboratory
1,2-Dibromoethane (Ethylene dibromide)	E504.1	Alpha
Lead	SW6020A	Alpha

E = Environmental Protection Agency (EPA) Method
SW = SW-846 Test Methods for Evaluating Solid Waste, 3rd Edition, Revision 4, 1996.

The data were assessed using the MMR SPEIM, Long Term Monitoring (LTM), and Operations and Maintenance (O&M) Program, Quality Assurance Project Plan (QAPP)[1],

[1] AFCEE. 2009 (April). *Quality Assurance Project Plan for the MMR SPEIM/LTM/O&M Program*. Prepared by CH2M HILL for AFCEE/MMR Installation Restoration Program, Otis Air National Guard Base, MA.

QAPP Addendum[2], and the U.S. Environmental Protection Agency (USEPA) Region I Data Validation Functional Guidelines (VFGs)[3]. The assessment included a review of the following:

- Sample delivery and condition
- Chain-of-custody documentation
- Holding-time compliance
- Required quality control (QC) samples at the specified frequencies
- Method blanks
- Laboratory control spiking samples
- Surrogate spike recoveries
- Matrix spike/matrix spike duplicate (MS/MSD) samples on a site/location basis,
- Initial and continuing calibrations, and other method-specific criteria as defined by the QAPP and USEPA Region I VFGs

Field samples were reviewed to ascertain field compliance and data quality issues. This included a review of equipment blanks (EB) and the field duplicate.

Data were carried through USEPA Region I Tier II data validation for 93 percent of the SDGs and through USEPA Region I Tier III data validation for 7 percent of the SDGs. Data flags were assigned, if necessary, according to the MMR QAPP and USEPA Region I VFGs. These flags, and the reason for each flag, were entered into the electronic database and can be found in Table B2-2 (located at the end of this report). Multiple flags are routinely applied to specific sample method/matrix/analyte combinations, but only one final flag is assigned. A final flag is applied to the data and is the most conservative of the applied validation flags. The final flag also includes matrix and blank sample impacts.

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[2] AFCEE. 2009 (July). *Final Quality Assurance Project Plan Addendum Long-Term Monitoring and Operations and Maintenance Programs, Massachusetts Military Reservation and Hanscom Air Force Base, Massachusetts*. Prepared by HydroGeologic, Inc. for MMR Installation Restoration Program, Department of the Air Force Otis Air National Guard Base, MA.

[3] USEPA. 1996 (December). *USEPA Region I New England Data Validation Functional Guidelines for Evaluating Environmental Analyses.*

The data flags are listed in the MMR QAPP and USEPA Region I VFGs, and are defined as follows:

- No qualifier = Analyte was detected at the reported concentration.
- J = Analyte was detected at the reported concentration; the quantitation is an estimate.
- U = Analyte was analyzed for but not detected. The associated numerical value is the reporting limit (RL). This qualifier is also applied to results considered to be artifacts based on contamination in associated blanks.
- UJ = Analyte was analyzed for but not detected. The associated numerical value is the RL, which is estimated due to deficiencies in the QC criteria. This qualifier is also applied to results considered to be artifacts based on contamination in associated blanks and have other associated QC discrepancies.
- R = Analyte was rejected due to deficiencies in the ability to analyze the sample and meet QC criteria.
- X = Excluded. The data point is associated with reanalyses or diluted analyses and is excluded because another result has been selected as the definitive result for the analyte.

FINDINGS

Summaries of the data validation findings are contained in the following subsections and Table B2-2.

Sample Delivery and Condition

All samples were received in acceptable condition and were properly preserved. No sample condition flags were applied.

Holding Times

The holding-time criteria were met, with the following exceptions. Five samples were reanalyzed outside of the 24-hour analysis holding time required by the QAPP for Method E504.1. Two of the 1,2-dibromoethane results were detections above the RL and were qualified J; three of the 1,2-dibromoethane results were non-detections and were qualified UJ.

Two samples were extracted 11 hours and 14 hours outside of the 14-day preparation holding time required by the QAPP for Method E504.1. The 1,2-dibromoethane results for these two samples were non-detections and were qualified UJ.

Calibration

Initial, initial verification, and continuing calibrations were analyzed as required for every analytical batch and were in control. No calibration flags were applied.

Method Blanks

Method blanks were analyzed at the required frequency for each method. No method blank flags were applied.

Field Blanks

EBs were collected and analyzed at the required frequency. No field blank flags were applied.

Field Duplicates

One field duplicate was collected as required, and precision was acceptable overall. No field duplicate flags were applied.

Confirmation Column Precision

The primary and confirmation column precision for the Method E504.1 analyses were acceptable overall. No flags were applied.

Matrix Spike Samples

MS and laboratory duplicate (LD) samples were collected at the required frequency and provided overall acceptable accuracy and precision. No flags were applied.

Surrogates

Surrogate recoveries for each method were within the MMR QAPP and USEPA Region I VFG acceptance limits. No surrogate flags were applied.

Laboratory Control Samples

Laboratory control samples (LCS) and LCS duplicates (LCSD) were analyzed as required and were in control, with the following exception. The laboratory inadvertently left one LCSD unspiked for Method E504.1, which resulted in a zero percent recovery and a maximum exceedance for the LCS/LCSD relative percent difference (RPD). Furthermore, an MS/MSD was not requested or performed in conjunction with this LCSD to negate qualification based on the exceedances. All five associated 1,2-dibromoethane results were non-detections and were qualified UJ.

Chain of Custody

One chain-of-custody (CoC) anomaly was noted in the review. A single sample listed on one of the CoCs was not received by the laboratory; this sample was not collected by the field crew, and the analysis request was omitted. No flags were applied.

Excluded Samples

Several samples were flagged with an X appended to the laboratory-applied qualifier to denote that the results were removed due to required dilutions or reanalyses. Each removed data point was replaced with a result that was selected by the validator as the definitive result for the analyte. X-qualified data are not presented in Table B2-2, as the flag is not an indication of data quality, but a notation that the result was not used.

Overall Assessment

The goal of this assessment is to demonstrate that a sufficient number of representative samples were collected and that the resulting analytical data can be used to support the decision-making process. The procedures for assessing the precision, accuracy,

representativeness, completeness, and comparability parameters (PARCC) are addressed in the MMR QAPP and USEPA Region I VFGs. The following summary highlights the PARCC findings for the above-defined events:

1. The completeness goal for valid usable data is 95 percent for aqueous samples. Completeness for the FS-1 samples was 100 percent, and the completeness goal was met for all compounds.

2. The routinely acceptable performance of field and laboratory QC indicators (field duplicates, field blanks, laboratory blanks, MS/MSDs, surrogate spikes, LCS, and calibrations) generally shows that the precision and accuracy of the data meet project objectives. Accuracy and precision exceedances in the LCSD are due to documented laboratory error. Holding time exceedances were the result of unacceptable surrogate recoveries that required re-extraction and/or reanalysis.

3. Sample results are representative and comparable to field conditions and past historical data because the field sampling and laboratory analyses were performed using standardized and documented procedures as defined in project documents. In addition, all results were reported with industry standard units.

Table B2-2
Validation Flags[a]

Field ID	Method	Analyte	Final Result	Units	Final Flag	Reason
36MW0140-GW-062309-DIF	E504.1	1,2-Dibromoethane	0.010	µg/L	UJ	HTA
36MW1001A-GW-062309-DIF	E504.1	1,2-Dibromoethane	0.010	µg/L	UJ	HTA
36MW1001B-GW-062309-DIF	E504.1	1,2-Dibromoethane	0.048	µg/L	J	HTA
36MW1038B-GW-062309-DIF	E504.1	1,2-Dibromoethane	0.010	µg/L	UJ	HTA
36MW1040A-GW-062309-DIF	E504.1	1,2-Dibromoethane	0.047	µg/L	J	HTA
36SW0003-SW-070709	E504.1	1,2-Dibromoethane	0.010	µg/L	UJ	HTP
36SW4200-SW-070709	E504.1	1,2-Dibromoethane	0.010	µg/L	UJ	HTP
36MW1011A-GW-062309-DIF	E504.1	1,2-Dibromoethane	0.010	µg/L	UJ	LCSLX / LCSP
36MW1038A-GW-062309-DIF	E504.1	1,2-Dibromoethane	0.010	µg/L	UJ	LCSLX / LCSP
36MW1038C-GW-062309-DIF	E504.1	1,2-Dibromoethane	0.010	µg/L	UJ	LCSLX / LCSP
36MW1040B-GW-062309-DIF	E504.1	1,2-Dibromoethane	0.010	µg/L	UJ	LCSLX / LCSP
36PZ1001-GW-062309-DIF	E504.1	1,2-Dibromoethane	0.010	µg/L	UJ	LCSLX / LCSP

[a] Only field samples and field duplicates, if applicable, are reported in this table.

Table sorted by Reason, Analyte and Field ID.

Notes:

HTA = Analytical holding time exceeded

HTP = Preparation holding time exceeded

LCSLX = LCS and/or LCSD recovery below 10%

LCSP = LCS/LCSD RPD criteria exceeded

µg/L = micrograms per liter

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Location	Sample ID	Date	Test	Type	Analyte	Matrix	Depth	Analyte Result	DL	RL	Units	Qual
36EW0001	36EW0001-GW-061009	6/10/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	123.74	0.012	0.003	0.01	µg/L	
36EW0001	36EW0001-WG-121509	12/15/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	123.74	0.017	0.003	0.01	µg/L	
36EW0005	36EW0005-GW-061009	6/10/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	155.15	0.022	0.003	0.01	µg/L	
36EW0005	36EW0005-WG-121509	12/15/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	155.15	0.027	0.003	0.01	µg/L	
36EW0011	36EW0011-GW-061009	6/10/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	213.17	0.177	0.003	0.01	µg/L	
36EW0011	36EW0011-WG-121509	12/15/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	213.17	0.126	0.003	0.01	µg/L	
36EW4020	36EW4020-GW-062609	6/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	18.5	ND	0.003	0.01	µg/L	U
36EW4084	36EW4084-GW-062509	6/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	19	ND	0.003	0.01	µg/L	U
36EW4135	36EW4135-GW-062509	6/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	18.5	ND	0.003	0.01	µg/L	U
36MW0002	36MW0002-GW-061609	6/16/2009	SW6020	N1	LEAD	WG	51.46	30.7	0.026	0.5	µg/L	
36MW0007	36MW0007-GW-061609	6/16/2009	SW6020	N1	LEAD	WG	51	11.5	0.026	0.5	µg/L	
36MW0131A	36MW0131A-GW-062609 DIF	6/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	182.5	BRL	0.003	0.01	µg/L	J
36MW0131B	36MW0131B-GW-062609 DIF	6/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	136.5	ND	0.003	0.01	µg/L	U
36MW0131C	36MW0131C-GW-062609 DIF	6/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	87.5	ND	0.003	0.01	µg/L	U
36MW0132A	36MW0132A-GW-062509 DIF	6/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	187.5	ND	0.003	0.01	µg/L	U
36MW0132B	36MW0132B-GW-062509 DIF	6/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	137.5	ND	0.003	0.01	µg/L	U
36MW0132C	36MW0132C-GW-062509 DIF	6/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	80.5	ND	0.003	0.01	µg/L	U
36MW0140	36MW0140-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	137.5	ND	0.003	0.01	µg/L	UJ
36MW0143	36MW0143-GW-062509 DIF	6/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	167.5	ND	0.003	0.01	µg/L	U
36MW0143	36MW0143-GW-062509-FD DIF	6/25/2009	E504.1	FD1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	167.5	ND	0.003	0.01	µg/L	U
36MW0501	36MW0501-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	147.5	ND	0.003	0.01	µg/L	U
36MW0504	36MW0504-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	179.5	ND	0.003	0.01	µg/L	UJ
36MW1001A	36MW1001A-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	147.5	ND	0.003	0.01	µg/L	UJ
36MW1001B	36MW1001B-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	97.5	0.048	0.003	0.01	µg/L	J
36MW1001B	36MW1001B-WG-121509-DIF	12/15/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	97.5	0.011	0.003	0.01	µg/L	
36MW1003A	36MW1003A-GW-062609 DIF	6/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	151.6	BRL	0.003	0.01	µg/L	J
36MW1010A	36MW1010A-GW-062509 DIF	6/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	225.5	ND	0.003	0.01	µg/L	U
36MW1010B	36MW1010B-GW-062509 DIF	6/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	162.5	ND	0.003	0.01	µg/L	U
36MW1010C	36MW1010C-GW-062509 DIF	6/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	83	ND	0.003	0.01	µg/L	U
36MW1011A	36MW1011A-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	97.5	ND	0.003	0.01	µg/L	UJ
36MW1011B	36MW1011B-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	22.5	ND	0.003	0.01	µg/L	U
36MW1012A	36MW1012A-GW-062509 DIF	6/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	146.6	ND	0.003	0.01	µg/L	U
36MW1012B	36MW1012B-GW-062509 DIF	6/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	75.4	0.016	0.003	0.01	µg/L	
36MW1012C	36MW1012C-GW-062509 DIF	6/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	20.1	ND	0.003	0.01	µg/L	U
36MW1014A	36MW1014A-GW-062609 DIF	6/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	96	ND	0.003	0.01	µg/L	U
36MW1014B	36MW1014B-GW-062609 DIF	6/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	20.6	ND	0.003	0.01	µg/L	U
36MW1036A	36MW1036A-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	260.48	ND	0.003	0.01	µg/L	U
36MW1036B	36MW1036B-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	221.4	ND	0.003	0.01	µg/L	U
36MW1036C	36MW1036C-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	172.63	0.011	0.003	0.01	µg/L	

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Location	Sample ID	Date	Test	Type	Analyte	Matrix	Depth	Analyte Result	DL	RL	Units	Qual
36MW1038A	36MW1038A-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	242.15	ND	0.003	0.01	µg/L	UJ
36MW1038B	36MW1038B-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	201.5	ND	0.003	0.01	µg/L	UJ
36MW1038C	36MW1038C-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	91.5	ND	0.003	0.01	µg/L	UJ
36MW1040A	36MW1040A-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	216.12	0.047	0.003	0.01	µg/L	J
36MW1040B	36MW1040B-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	130.9	ND	0.003	0.01	µg/L	UJ
36MW1041A	36MW1041A-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	221.5	0.857	0.003	0.01	µg/L	
36MW1041B	36MW1041B-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	152.15	ND	0.003	0.01	µg/L	U
36MW1041C	36MW1041C-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	132.25	ND	0.003	0.01	µg/L	U
36MW1043A	36MW1043A-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	252.38	ND	0.003	0.01	µg/L	U
36MW1043B	36MW1043B-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	162.4	0.028	0.003	0.01	µg/L	
36PLT02001	36PLT02001-WW-062409	6/24/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.091	0.003	0.01	µg/L	
36PLT02001	36PLT02001-WW-072709	7/27/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.085	0.003	0.01	µg/L	
36PLT02001	36PLT02001-WW-082809	8/28/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.093	0.003	0.01	µg/L	
36PLT02001	36PLT02001-WW-092509	9/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.089	0.003	0.01	µg/L	
36PLT02001	36PLT02001-WW-102609	10/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.093	0.003	0.01	µg/L	
36PLT02001	36PLT02001-WW-112409	11/24/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.072	0.003	0.01	µg/L	
36PLT02001	36PLT02001-WW-122809	12/28/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.077	0.003	0.01	µg/L	
36PLT02002	36PLT02002-WW-062409	6/24/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.043	0.003	0.01	µg/L	
36PLT02002	36PLT02002-WW-072709	7/27/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.044	0.003	0.01	µg/L	
36PLT02002	36PLT02002-WW-082809	8/28/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.054	0.003	0.01	µg/L	
36PLT02002	36PLT02002-WW-092509	9/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.056	0.003	0.01	µg/L	
36PLT02003	36PLT02003-WW-062409	6/24/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.003	0.01	µg/L	U
36PLT02003	36PLT02003-WW-072709	7/27/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.003	0.01	µg/L	U
36PLT02003	36PLT02003-WW-082809	8/28/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.011	0.003	0.01	µg/L	
36PLT02003	36PLT02003-WW-092509	9/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.019	0.003	0.01	µg/L	
36PLT02003	36PLT02003-WW-102609	10/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.027	0.003	0.01	µg/L	
36PLT02003	36PLT02003-WW-112409	11/24/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.044	0.003	0.01	µg/L	
36PLT02003	36PLT02003-WW-122809	12/28/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		0.035	0.003	0.01	µg/L	
36PLT02004	36PLT02004-WW-102609	10/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.003	0.01	µg/L	U
36PLT02004	36PLT02004-WW-112409	11/24/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		BRL	0.003	0.01	µg/L	J
36PLT02004	36PLT02004-WW-122809	12/28/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		BRL	0.003	0.01	µg/L	J
36PLT02005	36PLT02005-WW-062409	6/24/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.003	0.01	µg/L	U
36PLT02005	36PLT02005-WW-072709	7/27/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.003	0.01	µg/L	U
36PLT02005	36PLT02005-WW-082809	8/28/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.003	0.01	µg/L	U
36PLT02005	36PLT02005-WW-092509	9/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.003	0.01	µg/L	U
36PLT02005	36PLT02005-WW-102609	10/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.003	0.01	µg/L	U
36PLT02005	36PLT02005-WW-112409	11/24/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.003	0.01	µg/L	U
36PLT02005	36PLT02005-WW-122809	12/28/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WW		ND	0.003	0.01	µg/L	U
36PZ1001	36PZ1001-GW-062309-DIF	6/23/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	4.5	ND	0.003	0.01	µg/L	UJ

Attachment B-2
Analytical Laboratory Results, June - December 2009
FS-1 2009 Summary Letter Report

Location	Sample ID	Date	Test	Type	Analyte	Matrix	Depth	Analyte Result	DL	RL	Units	Qual
36PZ1002A	36PZ1002A-GW-062509	6/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	127.5	ND	0.003	0.01	µg/L	U
36PZ1002B	36PZ1002B-GW-062509 DIF	6/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	4.5	ND	0.003	0.01	µg/L	U
36PZ1003	36PZ1003-GW-062609 DIF	6/26/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	4.5	ND	0.003	0.01	µg/L	U
36PZ1010	36PZ1010-GW-062509	6/25/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WG	27.5	ND	0.003	0.01	µg/L	U
36SW0003	36SW0003-SW-070709	7/7/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WS		ND	0.003	0.01	µg/L	UJ
36SW0003	36SW0003-SW-090809	9/8/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WS		ND	0.003	0.01	µg/L	U
36SW0010	36SW0010-SW-090809	9/8/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WS		ND	0.003	0.01	µg/L	U
36SW0019	36SW0019-SW-070709	7/7/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WS		BRL	0.003	0.01	µg/L	J
36SW0019	36SW0019-SW-090809	9/8/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WS		0.023	0.003	0.01	µg/L	
36SW0036	36SW0036-SW-090809	9/8/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WS		ND	0.003	0.01	µg/L	U
36SW0200	36SW0200-SW-090809	9/8/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WS		ND	0.003	0.01	µg/L	U
36SW0303	36SW0303-SW-090809	9/8/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WS		ND	0.003	0.01	µg/L	U
36SW4188	36SW4188-SW-090809	9/8/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WS		ND	0.003	0.01	µg/L	U
36SW4200	36SW4200-SW-070709	7/7/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WS		ND	0.003	0.01	µg/L	UJ
36SW4200	36SW4200-SW-090809	9/8/2009	E504.1	N1	1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE)	WS		0.011	0.003	0.01	µg/L	

Data Source: AFCEE, February 2010, MMR-AFCEE Data Warehouse

Key:

BRL = below reporting limit
DL = detection limit
FD1 = field duplicate
J = estimated value
ND = nondetect
N1 = native sample
RL = reporting limit
U = undetected
UJ = estimated undetection
WG = groundwater
WS = surface water
WW = wastewater
µg/L = micrograms per liter

October 20, 2009

To: Rose Forbes, AFCEE

From: Robert Bogert, HGL Project Manager
Ken Rapuano, HGL Senior Chemist
Matt Beaupre, Alpha Project Manager
Scott Enright, Alpha Senior Chemist
Jim Todaro, Alpha QA Manager

RE: Method 504.1 for 1,2-dibromoethane (EDB): Results not reported to the Method Detection Limit (MDL)

Alpha Analytical Laboratories (Alpha) conducted a method detection limit (MDL) study in May 2009 prior to receiving samples for analysis by Method 504.1 for 1,2-dibromoethane (EDB). The MDL derived from this study was 0.0032 ug/L (Column A) and 0.0031 ug/L (Column B). These MDL values are sufficiently low to support the EDB reporting limit (RL) of 0.01 ug/L that is required for this project. Both columns are considered to have equal quantitative significance. The project-specific RL was established at 0.01 ug/L. Alpha's routine EDB RL is 0.02 ug/L, and this lower RL was confirmed by the addition of an initial calibration standard at 0.01 ug/L. Detected results should be reported down to the derived column-specific MDLs, unless instructed otherwise, using J qualifiers for results quantitated below the RL.

Summary of Problem

The EDB results presented in the Alpha data reports from June through August were compared against historical values by CH2M HILL. Historical data for samples for specific sample locations previously indicated routine detections between the RL and MDL whereas the recent data were reported as non-detect (ND). HGL reviewed the chromatograms for a selected project data package, and confirmed EDB peaks were evident for two of the reviewed samples chromatograms for which the reported EDB result was ND. The laboratory was contacted, and acknowledged that the observed peaks were EDB detections that were below the RL and that the data were not properly being reported to the MDL. All laboratory reports for EDB required review to determine if other low level detections were not reported.

Contributing Factors

Human error by Alpha's bench chemist was the cause of the problem. Prior to conducting the May 2009 MDL study, Alpha's standard RL for 504.1 analysis was 0.020 ug/L. This was also the lowest point of Alpha's standard five-point calibration. Alpha did incorporate a sixth calibration standard of 0.01 ug/L to meet the project required reporting level; however, the analyst failed to take this into account when evaluating the raw data and thus reported the results as if a 0.02 ug/L calibration

point was the lowest available. Since the results for certain samples that Alpha reported as ND were below the typical calibration point, the results were incorrectly reported as ND. This occurred despite communication at the beginning of the project between the laboratory manager and the analyst. This error was not detected by the laboratory quality control review, because the information necessary to correct a false-negative is not available during the normal review process. Similarly, the false-negative could not be caught during data validation without a Level IV review. The error was detected upon comparing current data with historic results. Historic data showed routine detections above the MDL but below the RL for certain locations that were currently being reported as ND. The comparison of current data with historical data prompted further review of all EDB lab reports prepared by Alpha.

Corrective Action

All prior lab reports have been re-evaluated to verify if previously reported ND values for EDB (i.e., results reported as "0.01 U") should have been reported as detected values above the MDL but below the RL. The project team, including the laboratory manager and QA manager, were informed that the correct reporting conventions for low-level detections (below the RL) must be implemented for all previously released reports. Revised reports have been reissued. Pending final review by HGL, the electronic data will be corrected. Table 1 presents a summary of the changes that were made based upon report review..

Preventative Action

Alpha will perform a greater level of quality control in reviewing the chromatograms prior to reporting data to ensure that the data reporting conventions have been correctly implemented in the reporting of EDB results. As a final check, HGL will review the chromatograms for all ND results (revised reports and future reports) to screen for possible detections that are not being reported. Alpha has adopted the MMR project specific RL and associated MDL from the May 2009 study as the laboratory standard RL and MDL. This change will minimize the potential for false-negatives due to human error.

Current Status

Laboratory reports have been reviewed by Alpha and transmitted to HGL. HGL performed a secondary review on all EDB results to verify that no other corrections were required. During the review HGL found one additional sample that was improperly reported as ND (L0908388-03). The results for this sample have also been corrected. HGL has forwarded the revised results to AFCEE and CH2M HILL. The data corrections are summarized in Table 1.

Table 1
Corrected EDB Results by Method 504.1

SDG	Sample No.	Sample ID	Result[1]	Flag	RFS	Task	Description	Project Impact
L0907370	-01	69MW0033A-GW-060509	0.003	J	25	LTM	FS-28 Baseline sampling of new wells	Result reported as ND in 16 September 2009 Data Presentation to regulators. Low detection at this location does not affect the decision making process; recommended that the incorrect data reporting should be noted in the Project Note.
L0907640	-01	36EW0001-GW-061009	0.012		50	LTM	FS-1 Triennial	Data has not been reported to regulators; value was used to calculate mass removal estimates, but impact is negligible.
L0908388	-03	36MW1043B-GW-062309	0.028		50	LTM	FS-1 Triennial	Data has not been reported to regulators; impact is negligible.
L0908388	-07	36MW1036C-GW-062309	0.011		50	LTM	FS-1 Triennial	Data has not been reported to regulators; impact is negligible.
L0908634	-05	36MW1003AGW062609	0.004	J	50	LTM	FS-1 Triennial	Data has not been reported to regulators; impact is negligible.
L0908634	-06	36MW0131AGW062609	0.006	J	50	LTM	FS-1 Triennial	Data has not been reported to regulators; impact is negligible.
L0908696	-15	69MW1279CGW070109 [2]	0.006	J	1	LTM	Connamesset Water Supply Well Sentry Well*	No impact. Result is below the RL, and results below the RL should not be reported.
L0909083	-03	36SW0019-SW-070709	0.0055	JP	17	LTM	FS-1 2nd Seasonal SW	No impact - The Quashnet bogs are not in production. The data is not needed to assess marketability of the cranberry crop.
L0910367	-03	27EW0002-GW-072909	0.008	J	12	LTM	LF-1 Q-SA EW	Data was not reported to regulators yet; value was used to calculate mass removal estimates, but impact is negligible.
L0912057	-15	36PLT02003-WW-082809	0.011		92	O&M	FS-1 Monthly Plant Sampling	Carbon change-out was implemented one-month late based on O&M protocol. However, there was no impact since effluent discharge criteria are still being met.
L0912057	-19	69PLT01002-WW-082809	0.0055	J	91	O&M	FS-28 Monthly Plant Sampling	The FS-28 plant was resampled out of normal cycle, based on historical patterns versus actual results. While the results (0.0055 J ug/L) from the sample collected on 28AUG09 would not have prompted a carbon-change out, the results (0.011 ug/L) of the resampling conducted 20 days later (17SEP09) did show the need for a carbon exchange. Effluent discharge criteria were met.
L0912058	-05	90PLT01023-WW-082809	0.011		102	O&M	FS-12 Treatment Facility Monthly Plant Sampling	Carbon change-out was implemented one-month late based on O&M protocol. However, there was no impact since effluent discharge criteria are still being met.

1. All previous data were reported as Non-Detect (ND). The results below reflect the corrected values based on review of the lab reports. All results are reported in ug/L.
2. Denotes ResWell Report requested. Result was reported as ND since it is below the RL of 0.01. A revised report has not issued.

-----Original Message-----
From: marchessault.paul@epamail.epa.gov
[mailto:marchessault.paul@epamail.epa.gov]
Sent: Friday, October 30, 2009 3:27 PM
To: Forbes, Rose Civ USAF AFCEE AFCEE/MMR
Cc: Len Pinaud; Elliot.Jacobs@state.ma.us; Davis, Jon Civ USAF AFCEE AFCEE/MMR; Minior, Mike Civ USAF AFCEE AFCEE/MMR
Subject: Re: HGL Review of EDB Data Packages - Corrective Action Report

Hi Rose,

I sent this information to Steve DiMattei, and here is his response:

"Looks pretty straight forward to me. Everything included in this memo looks plausible, and there is nothing here that would make me believe that something different happened. In summary, what I get from the memo is that the lab made a mistake by not reporting down to a lower detection limit (due to a lack of internal lab communication), HGL caught the mistake, and the lab admitted that they made a mistake. The lab went back and has corrected the data that was reported "ND" due to an incorrect reporting limit, and now has a plan in place to hopefully stop it from happening again".

Hope that answers your question. Have a great weekend.

Paul N. Marchessault, Remedial Project Manager Federal Facilities Superfund Section
1 Congress Street, Suite 1100
Boston, MA 02114
Phone: (617) 918-1388
Fax: (617) 918-1291

-----"Forbes, Rose Civ USAF AFCEE AFCEE/MMR" <Rose.Forbes@brooks.af.mil> wrote: -----

To: Paul Marchessault/R1/USEPA/US@EPA, "Len Pinaud" <leonard.pinaud@state.ma.us>, <Elliot.Jacobs@state.ma.us>
From: "Forbes, Rose Civ USAF AFCEE AFCEE/MMR" <Rose.Forbes@brooks.af.mil>
Date: 10/29/2009 08:34AM
cc: "Davis, Jon Civ USAF AFCEE AFCEE/MMR" <Jon.Davis@brooks.af.mil>, "Minior, Mike Civ USAF AFCEE AFCEE/MMR" <Mike.Minior@brooks.af.mil>
Subject: HGL Review of EDB Data Packages - Corrective Action Report

If you recall during the O&M/SPEIM update I gave at the last RPM meeting, I mentioned there were issues with reporting some 504.1 results from Alpha Analytical Lab. The analytical work was performed correctly but there was a mistake in the way the chemist reported some results. The attached corrective action report describes the issue and subsequent response in more detail and also provides a table of the impacted results.

Please let me know if you have any questions or require additional information.

Thanks

Rose

Rose Forbes, P.E.
HQ AFCEE/MMR
322 East Inner Road
Otis ANG Base MA 02542
Work: 508-968-4670 x 5613
Fax: 508-968-4476
Cell: 210-324-9495
rose.forbes@brooks.af.mil

[attachment "504 1 EDB Corrective Action_Final.pdf" removed by Paul Marchessault/R1/USEPA/US]

ATTACHMENT C

FS-1 Project Notes

FS-1 2008 Semiannual SPEIM Data Presentation
(July 2008 through December 2008)
371335-SPEIM-FS1-PRJNOT-002

Fuel Spill-1 Cyclic Pumping Optimization Evaluation
371335-SPEIM-FS1-PRJNOT-003

CH2MHILL	PROJECT NOTE	TASK ORDER 0003
		PROJECT NO. 371335
AFCEE SPEIM/LTM/O&M Otis ANG Base, Massachusetts AFCEE 4P08-FA8903-08-D-8769	DOCUMENT CONTROL NUMBER: 371335-SPEIM-FS1-PRJNOT-002 CDRL B008	PAGE 1 OF 3

Confirmation Of:	Date Held: 11 February 2009
☐ Meeting	Location:
☐ Change Notice	Date Issued: 08 June 2009
☒ General Project Note	Recorded By: Mark Hilyard
Subject: **FS-1 2008 SEMIANNUAL SPEIM DATA PRESENTATION (JULY 2008 THROUGH DECEMBER 2008)**	Issued By: Nigel Tindall CH2M HILL TECHNICAL SERVICES GROUP MANAGER

ITEM	REMARKS
1.0	**INTRODUCTION** This project note summarizes the Fuel Spill-1 (FS-1) 2008 semiannual data presentation for data collected for the FS-1 System Performance and Ecological Impact Monitoring (SPEIM) program between July 2008 and December 2008. The data presented includes results from the following sampling events: • Semiannual sampling of three extraction wells (December 2008) • Monthly sampling of treatment plant influent (July 2008 through December 2008) • Sampling of two monitoring wells (December 2008) • Summary of surface water sampling results (through September 2008) These data were presented to the regulatory agencies during the 11 February 2009 Technical Update meeting. The handouts for the presentation included three figures and presentation text slides. The data presentation is included as Attachment A.
2.0	**BACKGROUND** The FS-1 plume is detached from its source area and is defined as the extent of groundwater containing the contaminant of concern (COC), ethylene dibromide (EDB), at concentrations exceeding the Massachusetts Maximum Contaminant Level (MMCL) of 0.02 micrograms per liter (µg/L). The FS-1 EDB plume is being remediated through the operation of the FS-1 extraction, treatment, and discharge (ETD) system, which extracts contaminated groundwater via three extraction wells for a combined pumping rate of 515 gallons per minute.

Distribution: AFCEE: Jon Davis, Mike Minior, Rose Forbes, Bob Power, Admin. Record; EPA: Paul Marchessault, Bob Lim; MassDEP: Len Pinaud; Elliot Jacobs; Mashpee Consv: Drew McManus.; Haley & Aldrich: Bill Fisher; CCCGA: Brian Handy; CH2M HILL: Pat de Groot, Nigel Tindall, Doc. Control

ITEM	REMARKS
	Analytical data for the FS-1 plume have been collected through the SPEIM program since startup of the interim treatment system in 1999. This program was developed to monitor plume changes and to ensure the effective operation of the groundwater remediation systems; monitoring networks are also evaluated and optimized through the SPEIM program. The current approved FS-1 SPEIM monitoring network, including analytical scope and methods, is presented in the *Comprehensive Long Term Monitoring Plan*, which is available on-line at www.mmr.org under Plans and Protocols.
3.0	**RESULTS** An overview of ETD operations during the reporting period was presented by providing extraction well and treatment plant EDB influent concentrations detected during this reporting period. The extraction well and plant influent data were also presented on concentration trend plots to assess current trends against historic results. All the analytical data collected in 2008 for the FS-1 SPEIM program were included in the *Fuel Spill-1 2008 Summary Letter Report*, which was submitted in March 2009 (AFCEE 2009). December 2008 groundwater data from two monitoring wells, 36MW1001A and 36MW1001B, were presented and compared against the previous sampling results from June 2008. Surface water EDB results collected from the FS-1 surface water monitoring network between July 2006 and September 2008 were presented on a figure. The data presentation is included as Attachment A.
4.0	**CONCLUSIONS/RECOMMENDATIONS** • EDB concentrations at extraction wells and plant influent continue to decrease as the plume contracts in the aquifer. • Mass removal efficiency of 36EW0001 continues to decrease indicating that the portion of the FS-1 plume located within its capture zone to 36EW0001 has decreased in volume and concentration. • The EDB concentrations in groundwater at 36MW1001B (located downgradient of 36EW0001) decreased to below the MMCL of 0.02 µg/L, supporting the conceptual site model that the FS-1 plume has been cut off by 36EW0001. • The FS-1 annual SPEIM monitoring event will be conducted in June 2009 using the approved SPEIM network. • AFCEE will evaluate optimizing 36EW0001.

ITEM	REMARKS
5.0	**REGULATOR COMMENTS/ACTION ITEMS** No comments were received during the initial data presentation on 11 February 2009 or during a follow-up with the regulatory agencies during a subsequent Technical Update meeting on 08 April 2009. No additional comments regarding the results and conclusions presented during the annual data presentation were received or action items identified.
6.0	**REFERENCE** AFCEE (Air Force Center for Engineering and the Environment). 2009 (March). *Fuel Spill-1 2008 Summary Letter Report.* 371335-SPEIM-FS1-SLR-001. Prepared by CH2M HILL for AFCEE/MMR, Installation Restoration Program, Otis Air National Guard Base, MA.

Attachment:
Attachment A: FS-1 2008 Semiannual SPEIM Data Presentation, 11 February 2009 Technical Update Meeting

ATTACHMENT A

FS-1 2008 Semiannual SPEIM Data Presentation
11 February 2009 Technical Update Meeting

Overview (Figure 1):

- Semiannual sampling of 3 extraction wells (Dec-08).
- Monthly sampling of treatment plant influent (Jul-08 through Dec-08).
- Sampling of 2 monitoring wells (Dec-08).
- Summary of 2008 surface water sampling results (May-08 through Sept-08).

Results (Figure 2)

- EDB concentrations decreased between June-08 and Dec-08.
  - 36EW0001 from 0.033 µg/L to 0.018 µg/L (max: 0.844 µg/L in Jun-03)
  - 36EW0005 from 0.037 µg/L to 0.026 µg/L (max: 6.83 µg/L in Apr-99)
  - 36EW0011 from 0.219 µg/L to 0.157 µg/L (max: 4.03 µg/L in Apr-03)
  - 36PLT02001 from 0.146 µg/L to 0.107 µg/L (max: 2 µg/L in Nov-03)

- EDB at 36MW1001B decreased from 0.044 µg/L (June-08) to 0.016 µg/L (Dec-08); 35MW1001A remains ND.

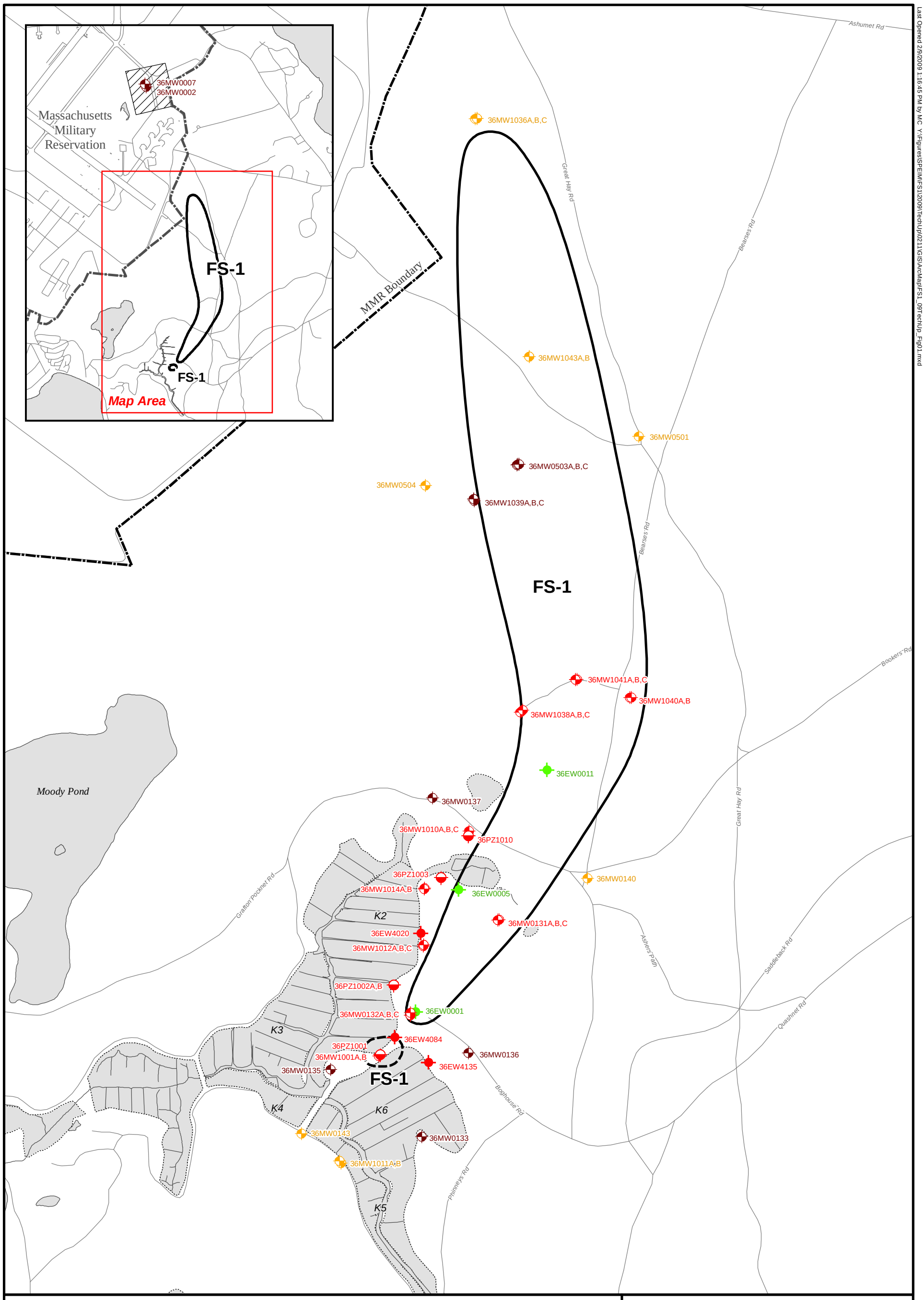
FS-1 2008 Semiannual SPEIM Data Presentation

Conclusions

- EDB concentrations in extraction well and plant influent continue to decrease as plume contracts within aquifer.
- Mass removal efficiency of 36EW0001 continues to decrease.
- Results at 36MW1001A,B support current conceptual site model.

Recommendation

- Evaluate optimization potential for 36EW0001.
- Annual sampling event using approved SPEIM network will be completed in May/June 2009.



Legend

- Proposed Plume Boundary (Dashed Where Inferred)
- Massachusetts Military Reservation Boundary
- FS-1 Source Area
- Bog/Wetland

Data Source: AFCEE, August 2008, MMR-AFCEE Data Warehouse

Well Type:

- Monitoring Well
- Piezometer
- Extraction Well

Sampling Frequency:

- Annual
- Triennial
- Biennial
- Semiannual

N

0 260 520 Feet

FIGURE 1

FS-1 SPEIM GROUNDWATER CHEMICAL MONITORING NETWORK AND CURRENT PLUME BOUNDARY

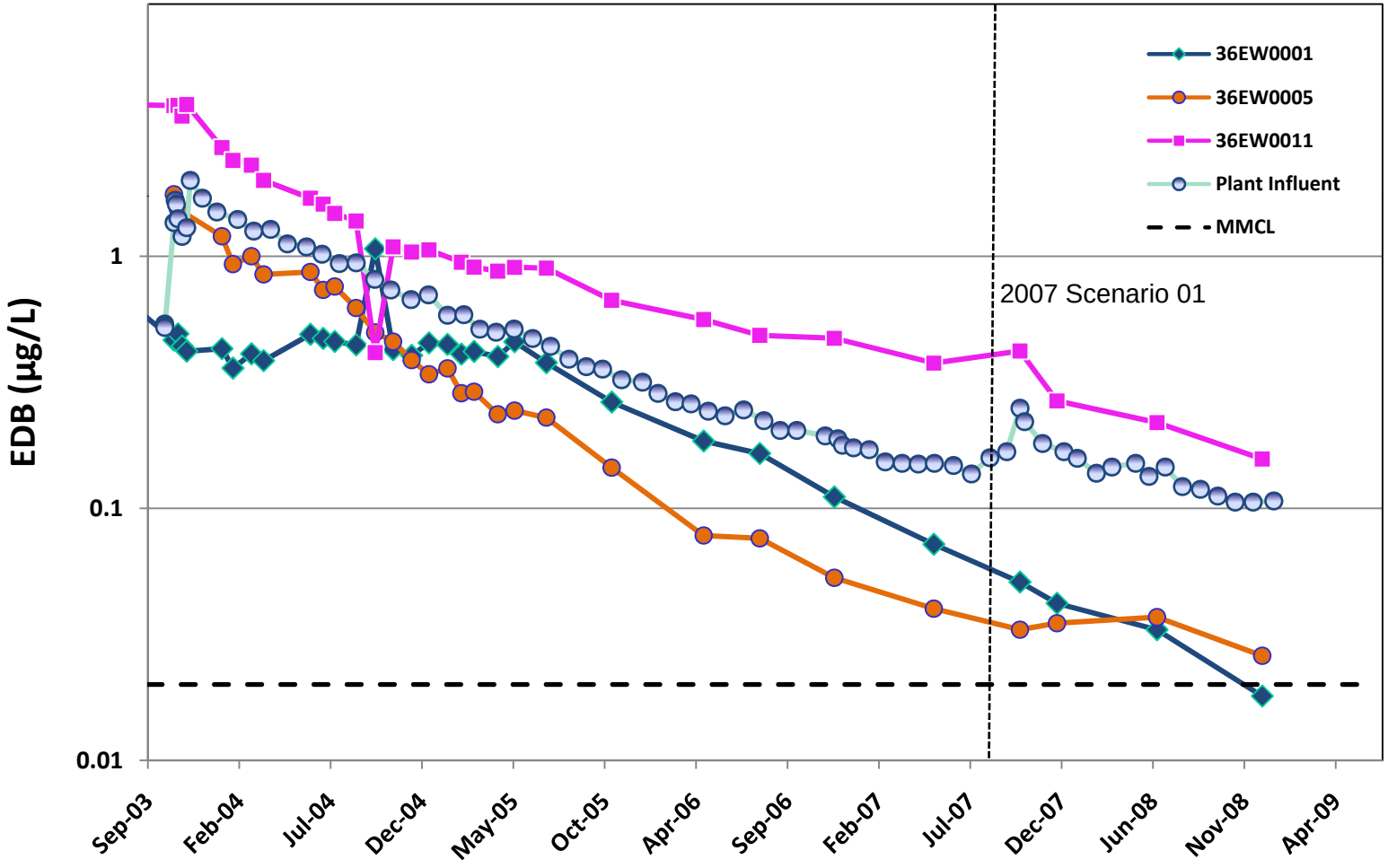
AFCEE - Massachusetts Military Reservation

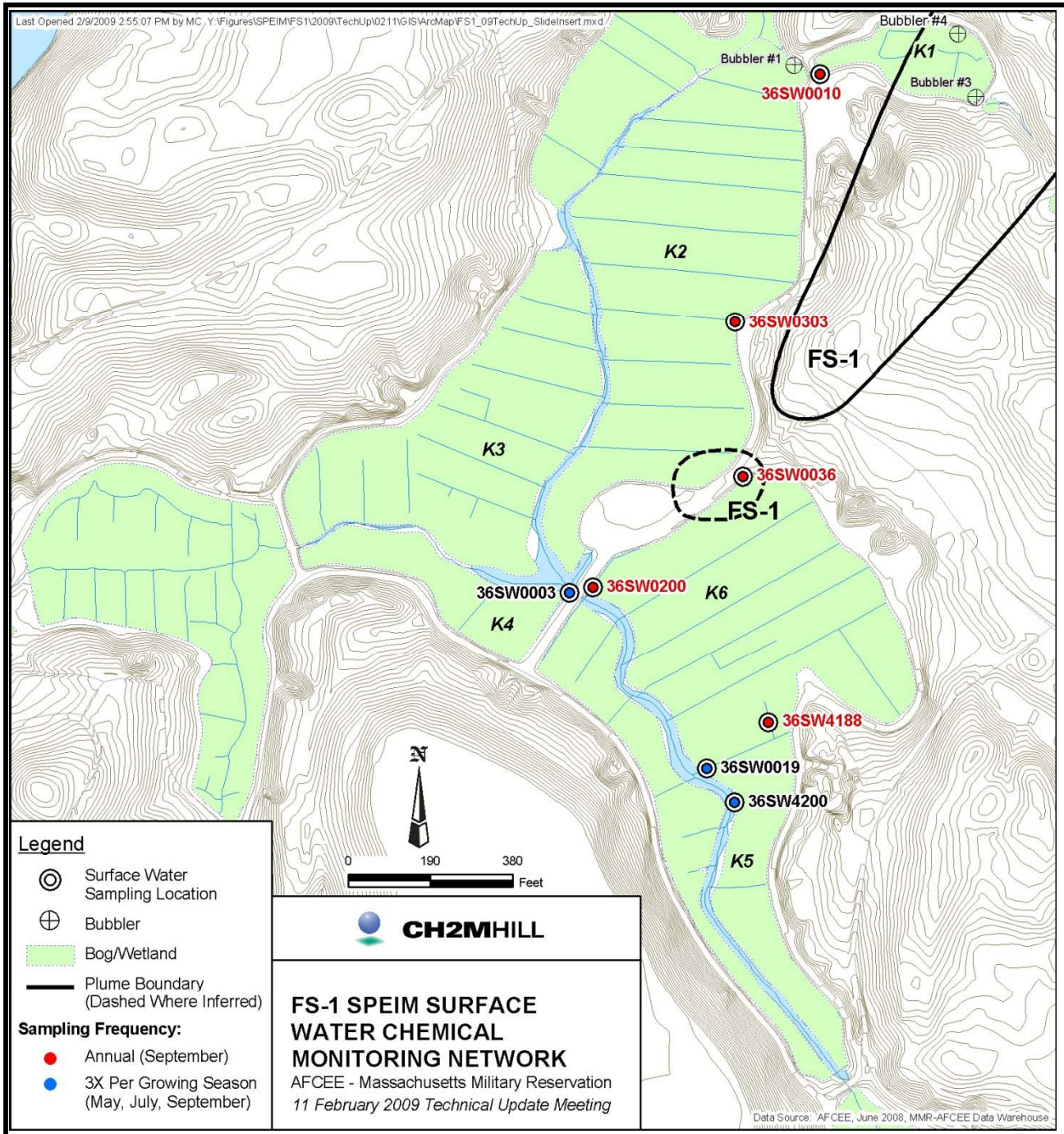
11 February 2009 Technical Update Meeting

CH2MHILL

FS-1 2008 Semiannual SPEIM Data Presentation

Figure 2 - Extraction Well and Plant Influent Sampling





EDB Concentrations (µg/L)

36SW0003		36SW0019		36SW4200	
07/25/06	ND	07/25/06	0.020	07/25/06	NS
08/22/06	NS	08/22/06	0.013	08/22/06	NS
09/27/06	ND	09/27/06	ND	09/27/06	ND
10/25/06	NS	10/25/06	0.026	10/25/06	NS
11/29/06	NS	11/29/06	BRL	11/29/06	NS
05/31/07	ND	05/31/07	ND	05/31/07	ND
07/18/07	ND	07/18/07	0.013	07/18/07	0.022
09/17/07	ND	09/17/07	ND	09/17/07	0.013
05/20/08	ND	05/20/08	ND	05/20/08	ND
07/15/08	ND	07/15/08	BRL	07/15/08	ND
09/09/08	ND	09/09/08	BRL	09/09/08	ND

36SW0010		36SW0036		36SW0200	
07/25/06	NS	07/25/06	ND	07/25/06	ND
08/22/06	NS	08/22/06	NS	08/22/06	ND
09/27/06	ND	09/27/06	ND	09/27/06	ND
10/25/06	NS	10/25/06	NS	10/25/06	ND
11/29/06	NS	11/29/06	NS	11/29/06	ND
05/31/07	NS	05/31/07	NS	05/31/07	NS
07/18/07	NS	07/18/07	NS	07/18/07	NS
09/17/07	ND	09/17/07	ND	09/17/07	ND
05/20/08	NS	05/20/08	NS	05/20/08	NS
07/15/08	NS	07/15/08	NS	07/15/08	NS
09/09/08	ND	09/09/08	ND	09/09/08	ND

36SW0303		36SW4188	
07/25/06	ND	07/25/06	ND
08/22/06	ND	08/22/06	ND
09/27/06	ND	09/27/06	ND
10/25/06	ND	10/25/06	ND
11/29/06	ND	11/29/06	ND
05/31/07	NS	05/31/07	NS
07/18/07	NS	07/18/07	NS
09/17/07	ND	09/17/07	ND
05/20/08	NS	05/20/08	NS
07/15/08	NS	07/15/08	NS
09/09/08	ND	09/09/08	ND

ND = Not Detected, NS = Not Sampled

*Data are unvalidated. BRL = below reporting limit

CH2MHILL	PROJECT NOTE	TASK ORDER 0003
		PROJECT NO. 371335
AFCEE SPEIM/LTM/O&M Otis ANG Base, Massachusetts AFCEE 4P08-FA8903-08-D-8769	DOCUMENT CONTROL NUMBER: 371335-SPEIM-FS1-PRJNOT-003 CDRL A001i	PAGE 1 OF 7

Confirmation Of:	Date Held: N/A
☐ Meeting	Location:
☐ Change Notice	Date Issued: 13 October 2009
☒ General Project Note	Recorded By: Mark Hilyard
Subject: **FUEL SPILL-1 CYCLIC PUMPING OPTIMIZATION EVALUATION**	Issued By: Nigel Tindall CH2M HILL TECHNICAL SERVICES GROUP MANAGER

ITEM	REMARKS
1.0	**INTRODUCTION/CONCEPT** This project note presents the results of a modeling-based optimization evaluation of using a cyclic pumping remedial approach at the Fuel-Spill-1 (FS-1) Extraction, Treatment, and Discharge (ETD) system at the Massachusetts Military Reservation (MMR). For this evaluation, a cyclic pumping approach entails periodic pumping of extraction wells for durations of at least one week or greater. The pumping schedule may entail cycling all extraction wells for a specific shut-down period or employing a staggered pumping schedule for individual wells or combinations thereof. The concept of cyclic pumping is to optimize the operation of a groundwater extraction system by taking advantage of natural hydraulic gradients to transport contamination to the extraction wells, while still maintaining the remedial objectives of the system as a whole.
2.0	**BACKGROUND** The FS-1 plume is detached from its source area and is defined as the extent of groundwater contaminated with the contaminant of concern (COC), ethylene dibromide (EDB), at concentrations exceeding the Massachusetts Maximum Contaminant Level (MMCL) of 0.02 micrograms per liter (µg/L). The FS-1 plume migrated approximately 6,400 feet beyond the MMR base boundary and followed the ambient groundwater flow field, eventually upwelling and discharging at detectable concentrations to the surface waters of the Quashnet River and cranberry bog complex (Figure 1). The FS-1 EDB plume is being remediated through the operation of the FS-1 ETD system, which extracts contaminated groundwater via three extraction wells for a combined pumping rate of 515 gallons per minute (gpm). The three operating extraction wells at FS-1 (36EW0001, 36EW0005, and 36EW0011) are arranged in an axial configuration hydraulically upgradient of the Quashnet River and bogs, with the primary objective for each well being mass removal (a fourth extraction well, 36EW0007, was shut down in 2007). The southernmost (and hydraulically downgradient) extraction well, 36EW0001, is also operated to inhibit further downgradient migration of the plume towards the river and bogs. At the time of the final ETD system startup in 2003, a small portion of the leading edge of the plume, which was hydraulically downgradient (i.e., south) of 36EW0001 at the time of startup, was expected to initially discharge to surface water of the Quashnet bogs at very low concentrations and then slowly dissipate and decrease to undetectable levels over time.

Distribution: AFCEE: Jon Davis, Mike Minior, Rose Forbes, Bob Power, Admin. Record; EPA: Paul Marchessault, Bob Lim; MassDEP: Len Pinaud; Elliott Jacobs; CH2M HILL: Pat de Groot, Nigel Tindall, Doc. Control

ITEM	REMARKS
	As stated in the Record of Decision (ROD) for the FS-1 plume (AFCEE 2000) the remedial action objectives for FS-1 are to: • Prevent or reduce exposure to groundwater containing EDB exceeding the safe drinking water standard of 0.02 µg/L. • Restore the aquifer to beneficial uses within a reasonable time frame; and • Prevent or reduce worker, recreational youth, and adult wader contact with Quashnet River water containing unacceptable concentrations of EDB and ingestion of fish exposed to Quashnet River water containing unacceptable concentrations of EDB. An integrated risk-based concentration of 6.5 µg/L for EDB in surface water was calculated (based on 10^{-3} risk), which incorporated each of the four receptor types listed in the third bullet listed above (AFCEE 2003). An aquatic organism and sediment screening benchmark of 31 µg/L was calculated for EDB (AFCEE 1998). Currently, the maximum EDB concentration observed in groundwater at FS-1 is 1.14 µg/L, therefore, it is very unlikely that concentrations above the surface water benchmarks mentioned above will be observed at the Quashnet River. Although not a remedial action objective as stated in the ROD, there is a strong desire (at the time of this evaluation) by stakeholders to achieve and maintain non-detects of EDB in the surface water of the Quashnet River and cranberry bog complex. The remedial action objective of restoring the aquifer to beneficial uses within a reasonable timeframe is to be achieved primarily through the operation of the FS-1 ETD system.
3.0	**OBJECTIVES/SIMULATION EVALUATION CRITERIA** The objective for this cyclic pumping evaluation at FS-1 was to identify, if possible, a cyclic pumping schedule that achieves similar or improved aquifer restoration timeframes against those predicted by the model under the current constant pumping configuration (2007 Scenario 01); while using less operational resources (electricity, carbon) by operating the system less. The evaluation criteria consist of specific model outputs that will be compared to current simulated operating conditions and include: 1) the plume transport simulations, 2) total EDB mass removed, 3) EDB mass discharge to bogs; and 4) projected annual electrical costs for each simulation. In addition, because the Quashnet River Bogs can be used to cultivate a commercial cranberry crop, no increase in the simulated discharge of EDB to the bogs would be allowed under any of preferred pumping configurations.
4.0	**MODEL DESCRIPTION** The 2006 FS-1 EDB plume shell (AFCEE 2007) was used with the 2004 FS-1 groundwater model (AFCEE 2005) to conduct this cyclic pumping evaluation. To simulate plume transport using cyclic pumping, the model was setup to run as a series of steady state simulations for each time step (pumping/resting period) over a simulation period. The predicted aquifer restoration time-frame for FS-1 under the current constant pumping configuration is approximately

ITEM	REMARKS
	25 years. Because the computational time and model file outputs for a typical 25-year simulation are prohibitively large, several preliminary cyclic pumping runs, which simulate the first five years of operation, were conducted to identify an optimal cyclic pumping scenario that appeared to best meet evaluation criteria developed for this assessment. The optimal cyclic pumping scenario was then run for the full 25-year simulation. A summary of pumping conditions associated with each preliminary cyclic pumping scenario, as well as the current pumping configuration (2007 Scenario 01) is provided in Table 1.
5.0	**RESULTS/DISCUSSION** The results of the preliminary cyclic pumping simulations are summarized in Table 2. This table provides animation screen captures of the final five-year time step for each of the four preliminary cyclic pumping transport model runs (CP01 through CP04), the current constant pumping configuration (2007 Scenario 01), and cyclic operation of four extraction wells at rates specified by the wellfield design report (CP-05) (AFCEE 2001). Each screen capture shows the predicted plume extent after five years of system operation and is accompanied by model-predicted EDB mass discharge to the bogs, EDB mass removed by the system, as well as projected annual electric costs for each scenario. Each sub-panel on the screen capture shows three views of the plume; a plan view, a cross-sectional view looking directly north, and a cross sectional view looking directly west. Each view depicts the distribution of the maximum EDB concentrations projected through the plume in the direction normal to the plan view. <u>Preliminary Model Results</u> Based upon a review of the five-year time step for each of the preliminary cyclic pumping results, the first two scenarios, CP-01 and CP-02 were not considered for further evaluation because each scenario predicted an increased discharge of EDB to the bogs. The additional discharge of the plume to the bogs is likely due to cyclical pumping at the most downgradient extraction well, 36EW0001, which may allow for portions of the FS-1 plume to bypass the extraction system during each resting period for this well (regardless of the duration of the resting period). In addition, cyclic pumping of the extraction wells either weekly or monthly appears to result in similar evaluation criteria (Table1). Yet, a weekly pumping schedule is likely to result in increased operations and maintenance (O&M) costs (operators switching valves, wear and tear on pumps) than monthly cycles. Because the monthly cyclic pumping time steps appear to result in similar evaluation criteria as weekly time steps, but with less potential O&M costs, only monthly time steps were further evaluated. Cyclic pumping scenarios CP-03 and CP-04 entails continuous operation of 36EW0001 (at 90 gpm and 150 gpm, respectively) and monthly operation of 36EW0005 and 36EW0011. As can be seen in Table 2, plume transport after five years under both scenarios is similar; however, more EDB may potentially discharge to the bogs when 36EW0001 is operated at the lower flow rate of 90 gpm. Finally, monthly cycling of all four extraction wells (36EW0007 was turned off in 2007 when optimized configuration 2007 Scenario 01 was implemented) was

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	simulated to determine if cyclic pumping of all four extraction wells would reduce or eliminate additional discharge of EDB to the bogs. The cyclic pumping of 36EW0007 appears to eliminate additional discharge of EDB to the bogs; however it results in higher electrical costs than all other cyclic pumping scenarios. Therefore, cyclic pumping of all four wells was not evaluated further. Scenario CP-04 was identified as the optimal cyclic pumping configuration because, when compared to the current pumping configuration (2007 Scenario 01) it has similar predicted aquifer restoration timeframe and mass discharge to the bogs, while using significantly less electricity (on an annual basis). Therefore, CP-04 was evaluated further by running a full 25-year simulation. Based in part on modeling results from the 25-year simulation of CP-04 (discussed below) an additional cyclic pumping scenario, CP-06, was evaluated by running a full 25-year simulation. Scenario CP-06 entailed operation of the FS-1 ETD system under 2007Scenario01 for approximately 6 years (at which time 36EW0001 could be turned off) then cyclic pumping of 36EW0005 and 36EW0011 until then end of the simulation run in 2032. <u>25-Year Simulation Results</u> Initially, cyclic pumping scenario CP-04 was simulated for a 25-year period since preliminary results (Table 2) indicated that it best met the evaluation criteria for this modeling exercise. The simulated migration of the FS-1 plume is presented as a series of three-panel figures (Figures 2a through 2e). These three-panel figures provide a comparison of simulated plume migration under current pumping conditions (2007 Scenario 01) and cyclic pumping conditions (Scenario CP-04 and Scenario CP-06) at the 2007.5, 2014.5, 2018, 2023 and 2032 time steps. Animations of the transport model simulations are included on a compact disk (Attachment A). In addition to the simulated migration of the plume under each of the modeled pumping scenarios, a summary of the model outputs (evaluation criteria) for CP-04 is provided in Table 3 and cumulative electrical consumption is shown in Figure 3. Under the current continuous pumping strategy (2007 Scenario 01) the aquifer is predicted to be remediated from south to north over time and extraction wells may be sequentially turned off based on model predictions of when no EDB concentrations above the MMCL is in groundwater adjacent to extraction well screens in the following order: 36EW0001 off around 2014, 36EW0005 off around 2017, and 36EW0011 off around 2023. Under the current pumping scenario, it is predicted that a relatively small, low concentration (< 0.1 µg/L) EDB plume will remain in a basal silt and is not predicted to be captured by the ETD system or migrate further downgradient. Cyclic pumping under Scenario CP-04 results in lower electrical costs on an annual basis (Figure 3). However, this scenario appears to result in longer aquifer restoration timeframes at two of the extraction wells: 36EW0001 off around 2018 and 36EW0005 off around 2032. Again, residual EDB is predicted to remain in the basal silt beyond the last simulation year (2032). The longer aquifer restoration timeframes, and therefore operational timeframe, predicted for 36EW0001 and 36EW0005 are thought to primarily be the result of EDB plume

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	mass that is allowed to migrate outside of the capture zone for the upgradient extraction wells during the rest periods (laterally and normal to the capture zone) which then are subsequently captured by the downgradient extraction wells. Based on a comparison of plume capture near 36EW0001 and 36EW0005 under the current scenario (2007 Scenario 01) and the cyclic pumping model run (CP-04) it appeared that the current pumping configuration was more efficient at remediating the aquifer in the vicinity of 36EW0001. Therefore, a sixth and final cyclic pumping scenario (CP-06), which simulated the operation of the ETD system using 2007 Scenario 01 until 2014 (when 36EW001 can be turned off) and then monthly cyclic pumping of 36EW0005 and 36EW0011, was run for a 25-year simulation period. Cyclic pumping at FS-1 under Scenario CP-06 results in similar aquifer restoration timeframes as Scenario CP-04 (Table 3) but with a higher cumulative electrical cost (Figure 3). The higher cumulative electrical cost is attributed to the continuous pumping of all three extraction wells until 2014, coupled with the EDB mass adjacent to 36EW00011 that is allowed to migrate past its capture zone, requiring a longer operational timeframe for 36EW0005.
6.0	**CONCLUSIONS** Model simulations of cyclic pumping of the FS-1 ETD system under Scenario CP-04 results in similar EDB mass removal estimates but with lower annual electrical costs than those predicted for the current pumping scenario (2007Scenario 01). However, these electrical savings are somewhat offset by the longer operational times required for each extraction well and the ETD system as a whole in order to achieve model-predicted aquifer restoration. The net electrical cost for cyclic pumping scenario CP-04 is approximately $62,000 less than the current scenario, however this difference is likely less than the additional operations and maintenance costs ne3eded to operate the system for the additional time needed to achieve site closure under cyclic pumping. <u>Application of Cyclic Pumping at Other MMR Sites</u> Although cyclic pumping does not appear to have immediate benefits at the FS-1 groundwater plume, this general pumping strategy should be evaluated at other MMR plumes. Based on an evaluation of the plume migration simulations at FS-1, the following considerations should be taken when evaluating cyclic pumping for other MMR sites: • A cyclic pumping strategy may not be effective at axial extraction well systems. Continued operation of the most downgradient extraction well will likely be necessary to maintain plume capture (if required). In addition, axial extraction systems are typically designed to rely on the operation of upgradient wells to establish a composite hydraulic capture zone wide enough to encompass the entire plume. For those systems where the plume width is very close to the width of the composite capture zone, cyclic pumping at the upgradient extraction wells may allow for additional mass to migrate further downgradient, requiring longer operational times for the downgradient extraction wells.

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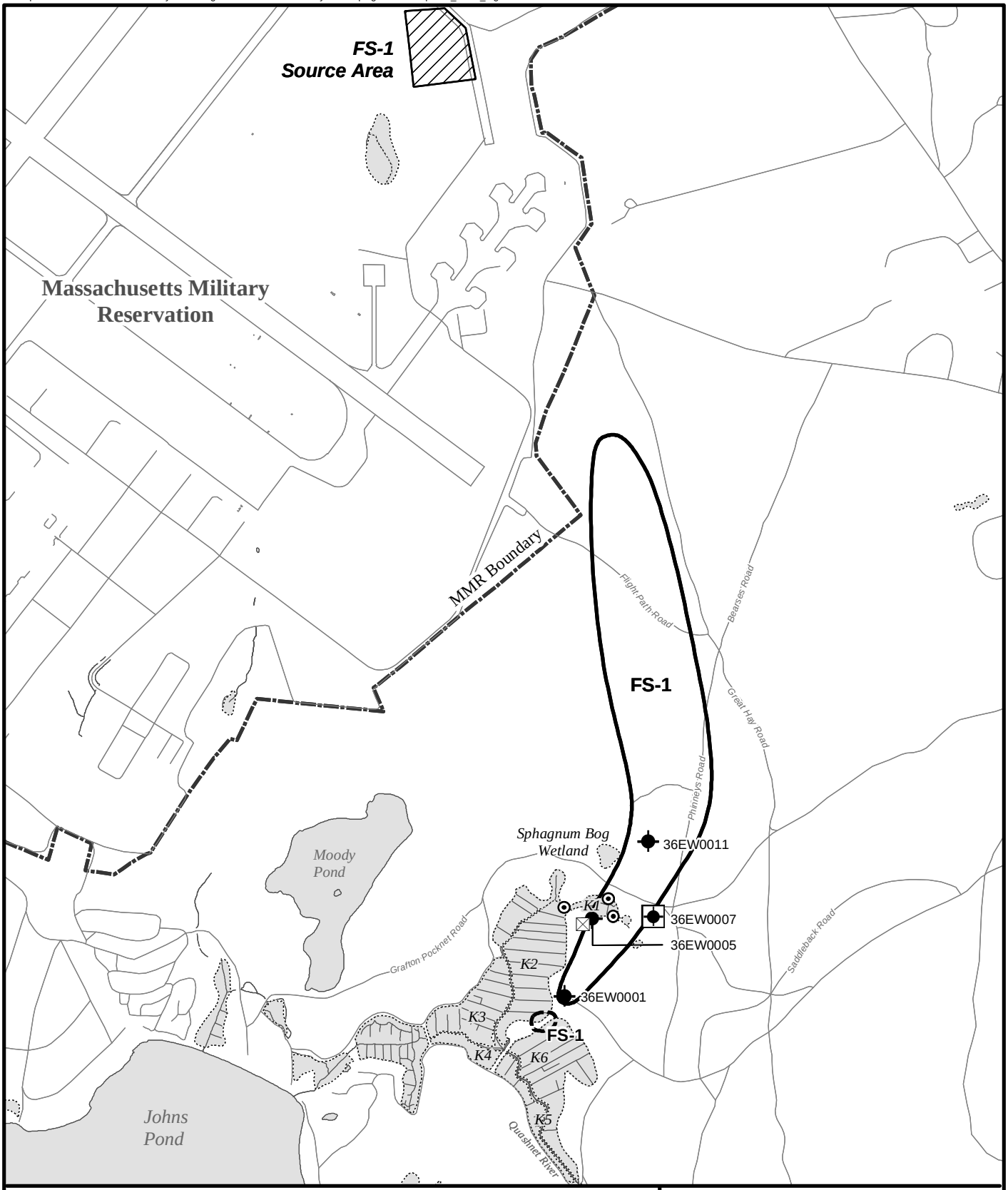
	• Cyclic pumping should be avoided at extraction wells that are located at the edge of a remedial systems composite hydraulic capture zone (if full capture is a remedial objective). Cyclic pumping of extraction wells located at the edge of a hydraulic capture zone may result in loss of plume capture. • Cyclic pumping may be most effective for extraction wells that have areas of high contaminant mass located well within the hydraulic capture zone for the well. Therefore, during the rest periods associated with each cycle period, portions of high concentration plume will not migrate beyond the capture zone for the well. For extraction wells at which the core of the plume is already being intercepted (such as 36EW0011 at FS-1) enough EDB mass likely bypasses the stagnation point for this well and effectively "feeds" downgradient wells for a longer period of time.
6.0	**REGULATOR COMMENTS/ACTION ITEMS** No comments were received from the Regulatory Agencies during a Technical Update meeting on 16 September 2009.
7.0	**REFERENCES** AFCEE (U.S. Air Force Center for Engineering and the Environment). 2007 (February). *FS-1 2006 EDB Plume Shell Update.* 337105-SPEIM-FS-1-PRJNOT-003. Prepared by CH2M HILL for AFCEE/MMR, Installation Restoration Program, Otis Air National Guard Base, MA. _____. 2005 (June). *Final Fuel Spill-1 2004 System Performance and Ecological Impact Monitoring Report.* 324146-SPEIM-FS-1-ANRPT-001. Prepared by CH2M HILL for AFCEE/MMR, Installation Restoration Program, Otis Air National Guard Base, MA. _____. 2003 (May). *Final Fuel Spill-1 2002 Annual System Performance and Ecological Impact Monitoring Report.* ENR-J23-35Z15616-M31-0003. Prepared by Jacobs Engineering Group Inc. for AFCEE/MMR, Installation Restoration Program, Otis Air National Guard Base, MA. _____. 2001 (December). *Final Fuel Spill-1 Wellfield Design Report.* AFC-J23-35S19902-M23-0005. Prepared by Jacobs Engineering Group Inc. for AFCEE/MMR, Installation Restoration Program, Otis Air National Guard Base, MA _____. 2000 (April). *Final Record of Decision Area of Contamination FS-1.* Submitted by Hazardous Waste Remedial Actions Program. Prepared for AFCEE/MMR, Installation Restoration Program, Otis Air National Guard Base, MA.

ITEM	REMARKS
	_____. 1998 (November). *Final Ethylene Dibromide: Derivation of Aquatic Screening Benchmarks.* Prepared by Sylvia S. Talmage, Oak Ridge National Laboratory, for AFCEE/MMR, Installation Restoration Program, Otis Air National Guard Base, MA.

Attachments:
Figure1: FS-1 Groundwater Plume and Treatment System
Figures 2a-2e: Simulated FS-1 EDB Plume Migrations
Figure 3: Cumulative Electricity Costs
Table 1: FS-1 Remediation System Pumping Schedule for Current and Cyclic Pumping Conditions
Table 2: Screen Capture and Model Outputs – 5-Year Time Step Preliminary Cyclic Pumping Simulations
Table 3: Pumping Schedule and Model Outputs – 25-Year Time Step
Attachment A: FS-1 Cyclic Pumping Optimization Simulations



Legend

Data Source: AFCEE, February 2009, MMR-AFCEE Data Warehouse

- Outflow Bubbler
- Extraction Well (On)
- Extraction Well (Off)
- Treatment Plant
- Massachusetts Military Reservation Boundary
- Plume Boundary (Dashed Where Inferred)
- Bog/Wetland
- Source Area

N

0 600 1,200 Feet

FIGURE 1

FS-1 GROUNDWATER PLUME AND TREATMENT SYSTEM

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FS-1 Cyclic Pumping Project Note

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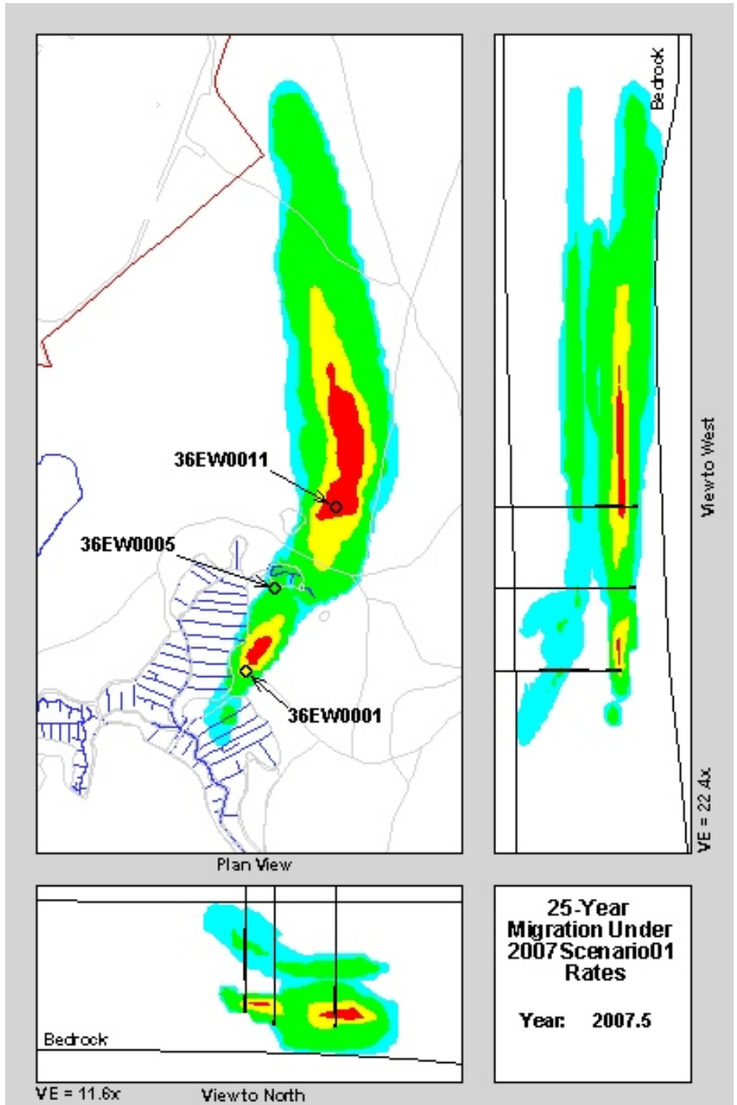
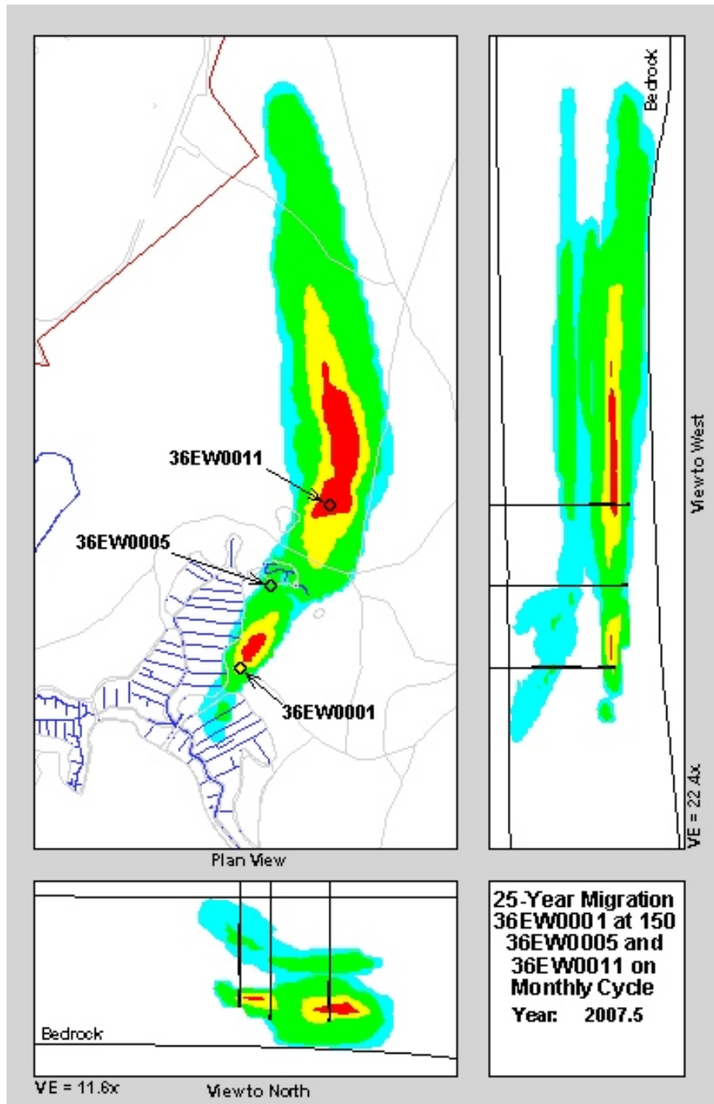
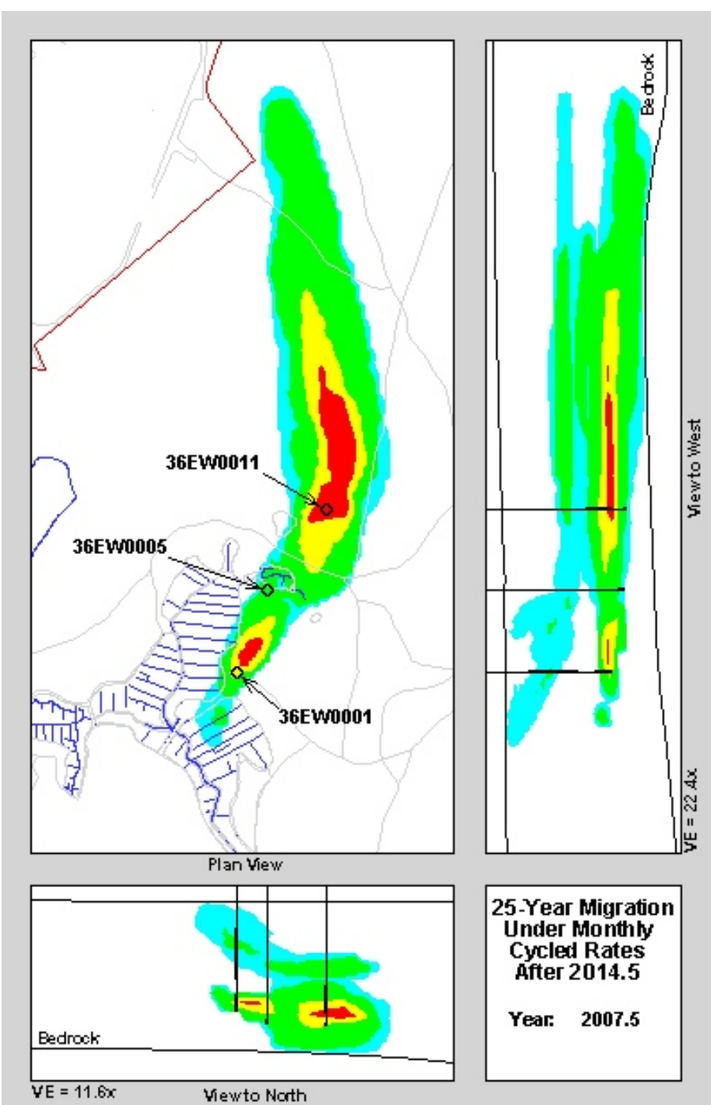
2007 Scenario 01



Cyclic Scenario CP-04



Cyclic Scenario CP-06



Legend

- EDB Concentration 0.02 - 0.1 µg/L
- EDB Concentration 0.1 - 1.0 µg/L
- EDB Concentration 1.0 - 2.0 µg/L
- EDB Concentration > 2.0 µg/L

Notes:
1). Plan view, view to north, and view to west depict the highest EDB concentration in the plume relative to each view
2). Transport modeling simulation represents EDB concentrations above MMCL of 0.02 µg/L

Source: FS-1 Groundwater Model

FIGURE 2a

SIMULATED FS-1 EDB PLUME MIGRATIONS 2007.5

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FS-1 Cyclic Pumping Project Note

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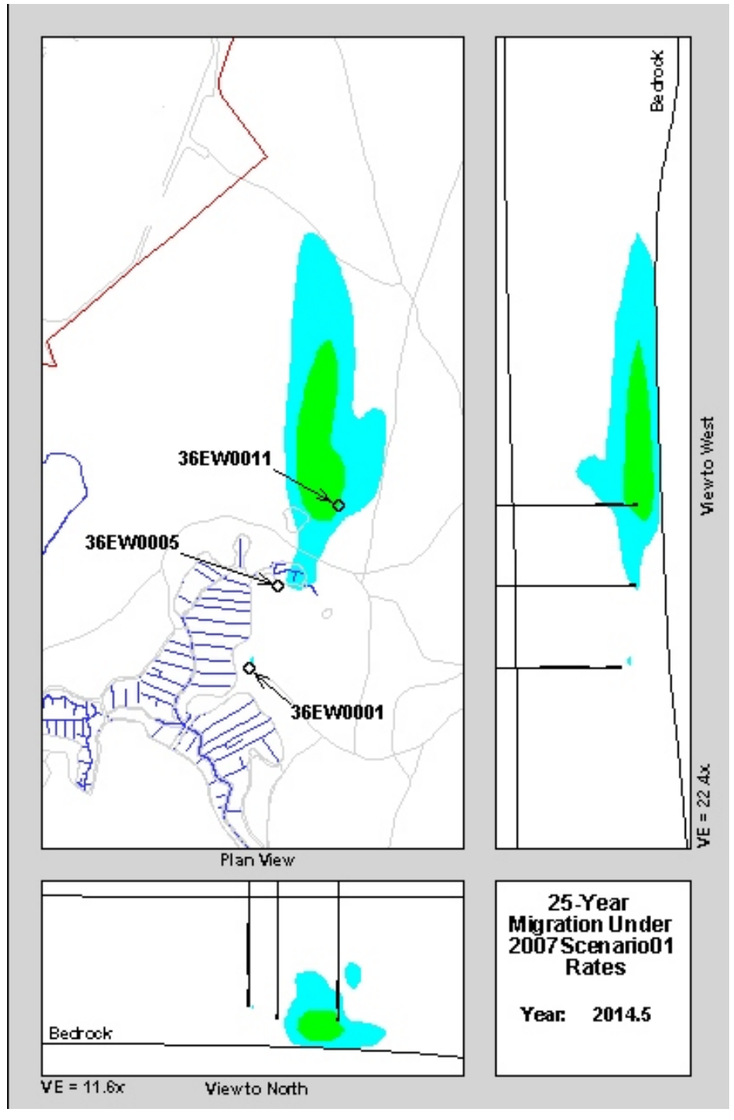
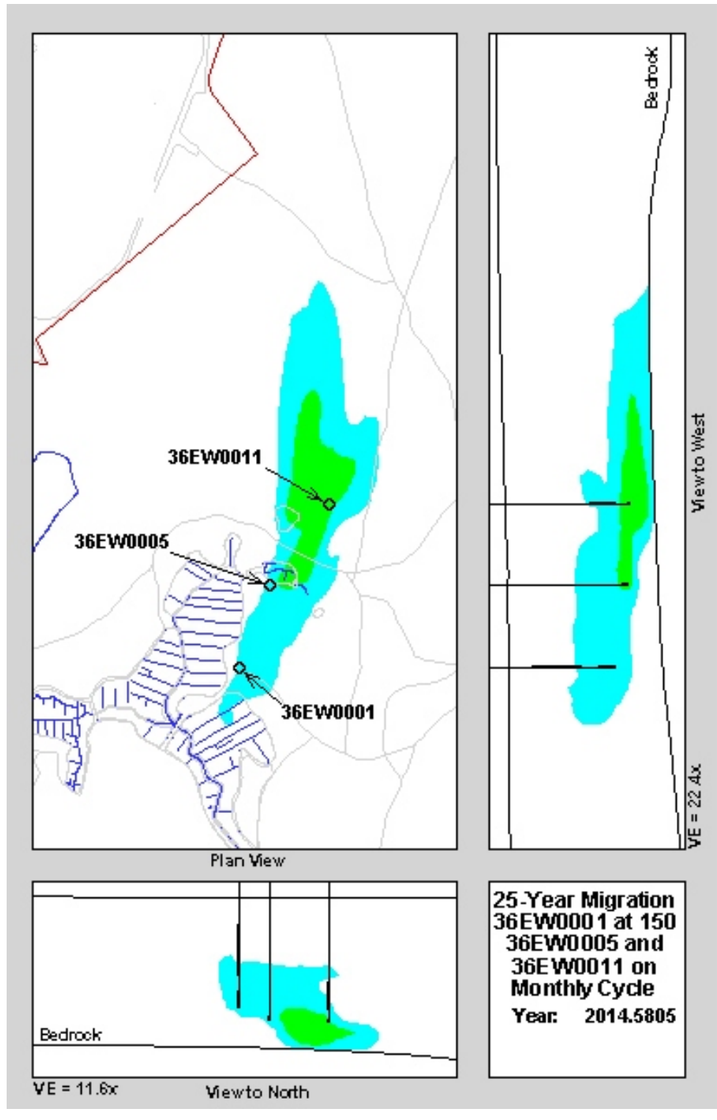
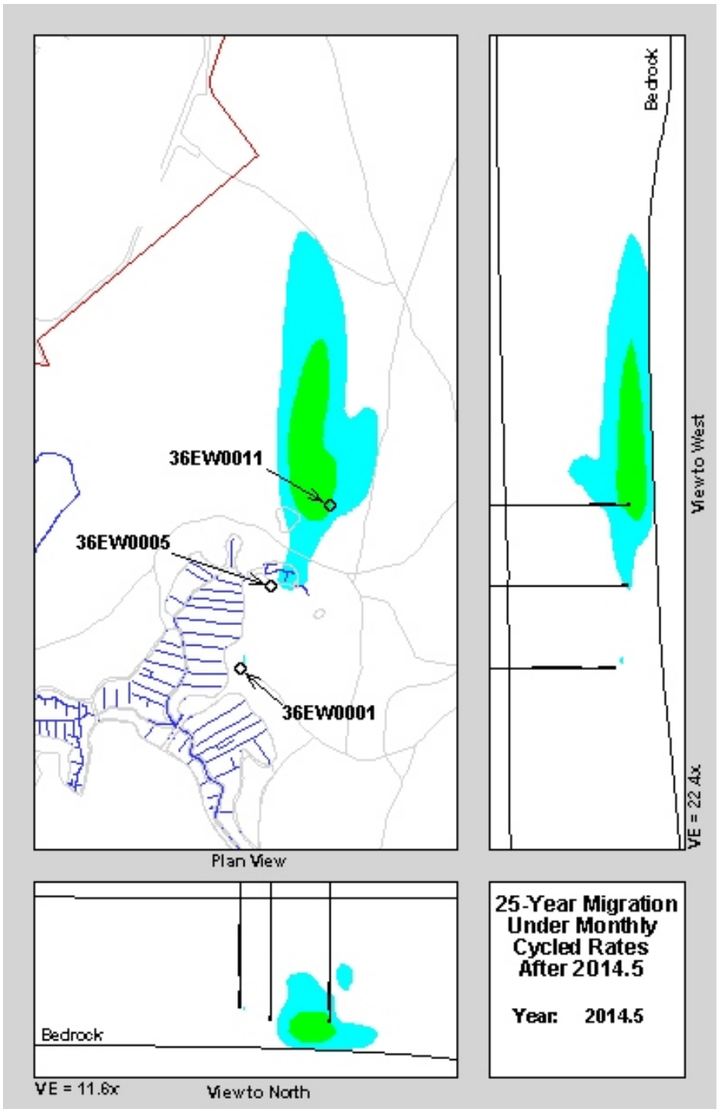
2007 Scenario 01



Cyclic Scenario CP-04



Cyclic Scenario CP-06



Legend

- EDB Concentration 0.02 - 0.1 µg/L
- EDB Concentration 0.1 - 1.0 µg/L
- EDB Concentration 1.0 - 2.0 µg/L
- EDB Concentration > 2.0 µg/L

Notes:
1). Plan view, view to north, and view to west depict the highest EDB concentration in the plume relative to each view
2). Transport modeling simulation represents EDB concentrations above MMCL of 0.02 µg/L

Source: FS-1 Groundwater Model

FIGURE 2b

SIMULATED FS-1 EDB PLUME MIGRATIONS 2014.5

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FS-1 Cyclic Pumping Project Note

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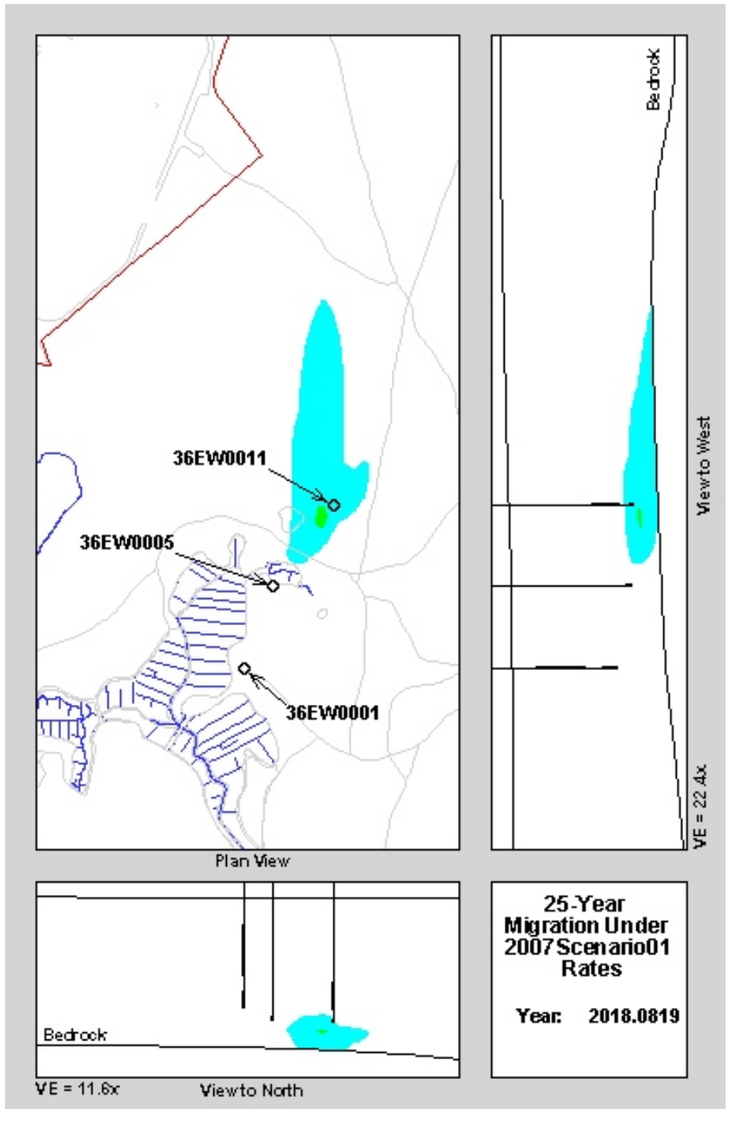
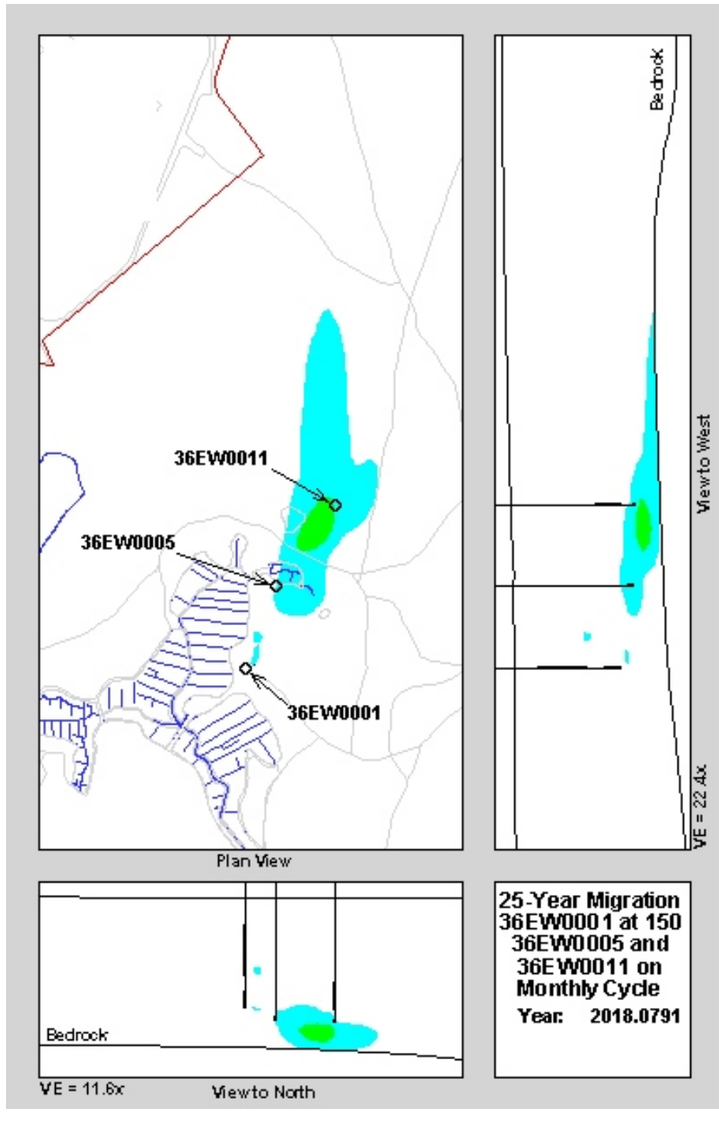
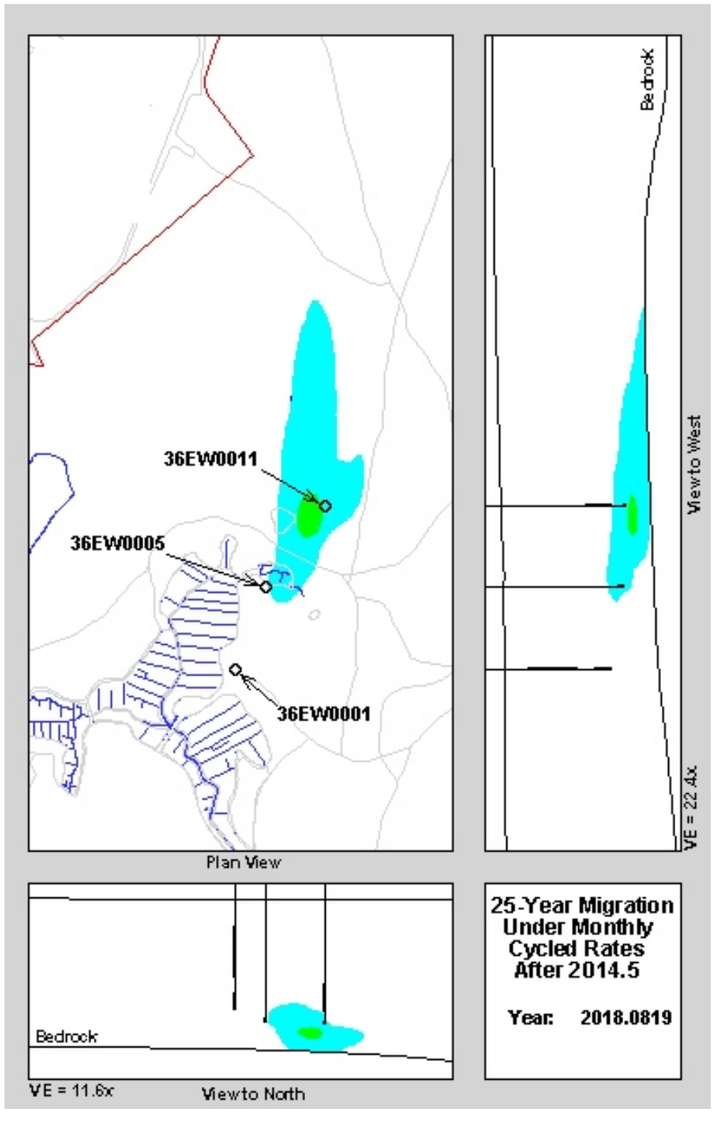
2007 Scenario 01



Cyclic Scenario CP-04



Cyclic Scenario CP-06



Legend

- EDB Concentration 0.02 - 0.1 µg/L
- EDB Concentration 0.1 - 1.0 µg/L
- EDB Concentration 1.0 - 2.0 µg/L
- EDB Concentration > 2.0 µg/L

Notes:
1). Plan view, view to north, and view to west depict the highest EDB concentration in the plume relative to each view
2). Transport modeling simulation represents EDB concentrations above MMCL of 0.02 µg/L

Source: FS-1 Groundwater Model

FIGURE 2c

SIMULATED FS-1 EDB PLUME MIGRATIONS 2018

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FS-1 Cyclic Pumping Project Note

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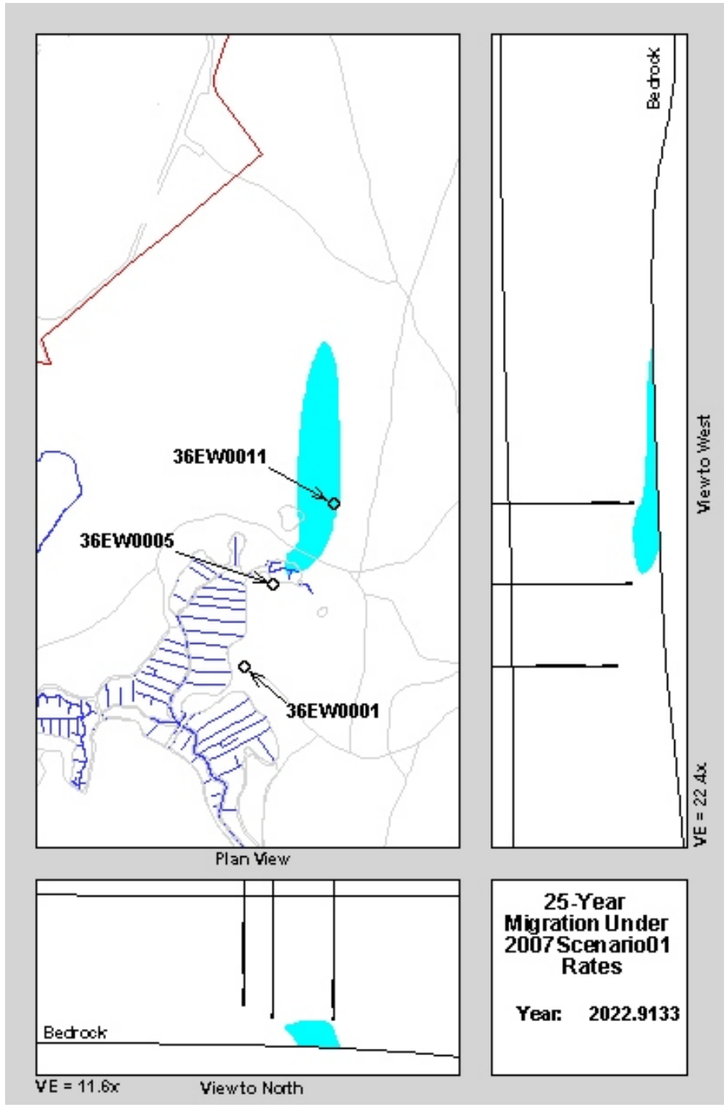
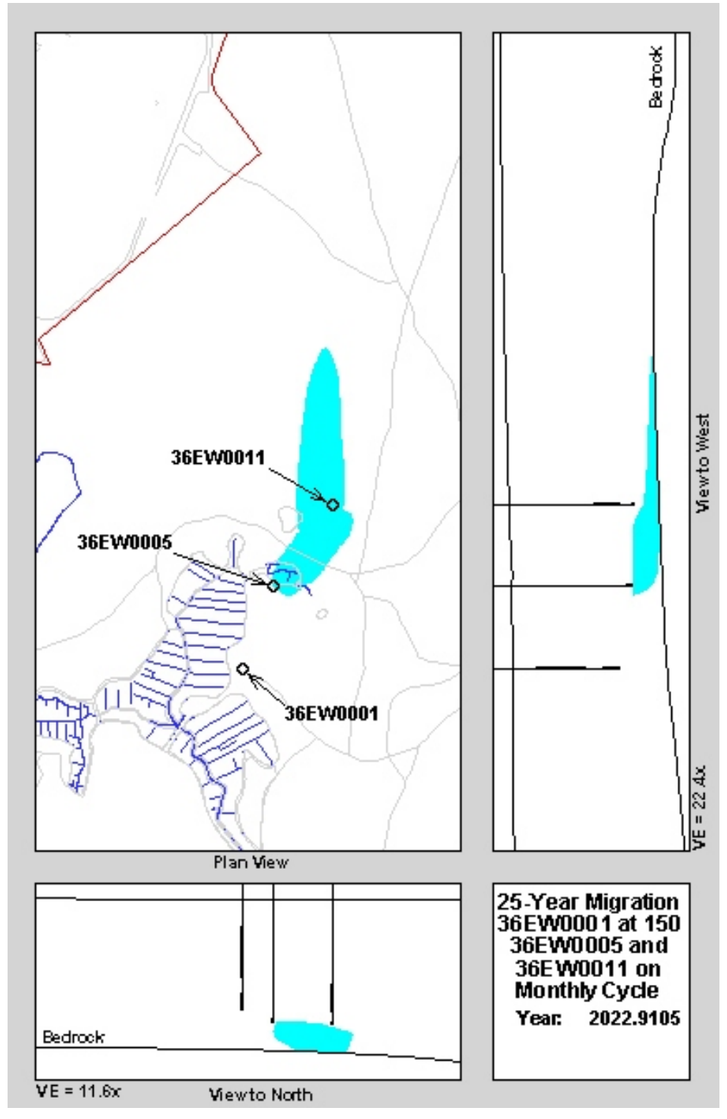
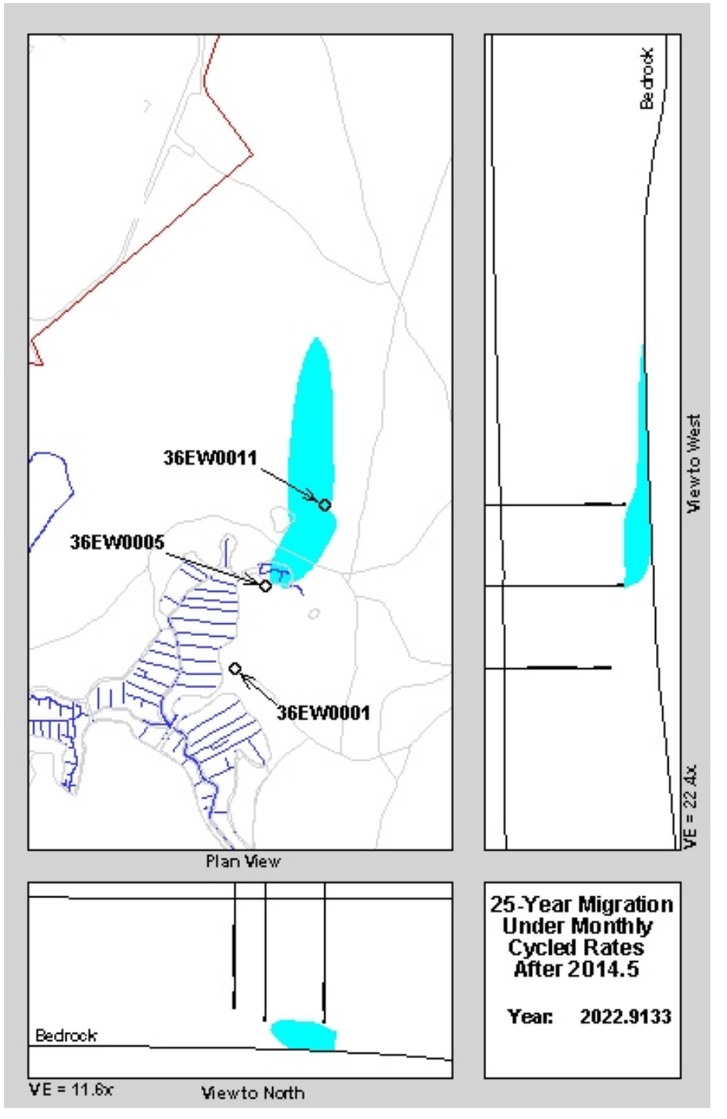
2007 Scenario 01



Cyclic Scenario CP-04



Cyclic Scenario CP-06



Legend

- EDB Concentration 0.02 - 0.1 µg/L
- EDB Concentration 0.1 - 1.0 µg/L
- EDB Concentration 1.0 - 2.0 µg/L
- EDB Concentration > 2.0 µg/L

Notes:
1). Plan view, view to north, and view to west depict the highest EDB concentration in the plume relative to each view
2). Transport modeling simulation represents EDB concentrations above MMCL of 0.02 µg/L

Source: FS-1 Groundwater Model

FIGURE 2d

SIMULATED FS-1 EDB PLUME MIGRATIONS 2023

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FS-1 Cyclic Pumping Project Note

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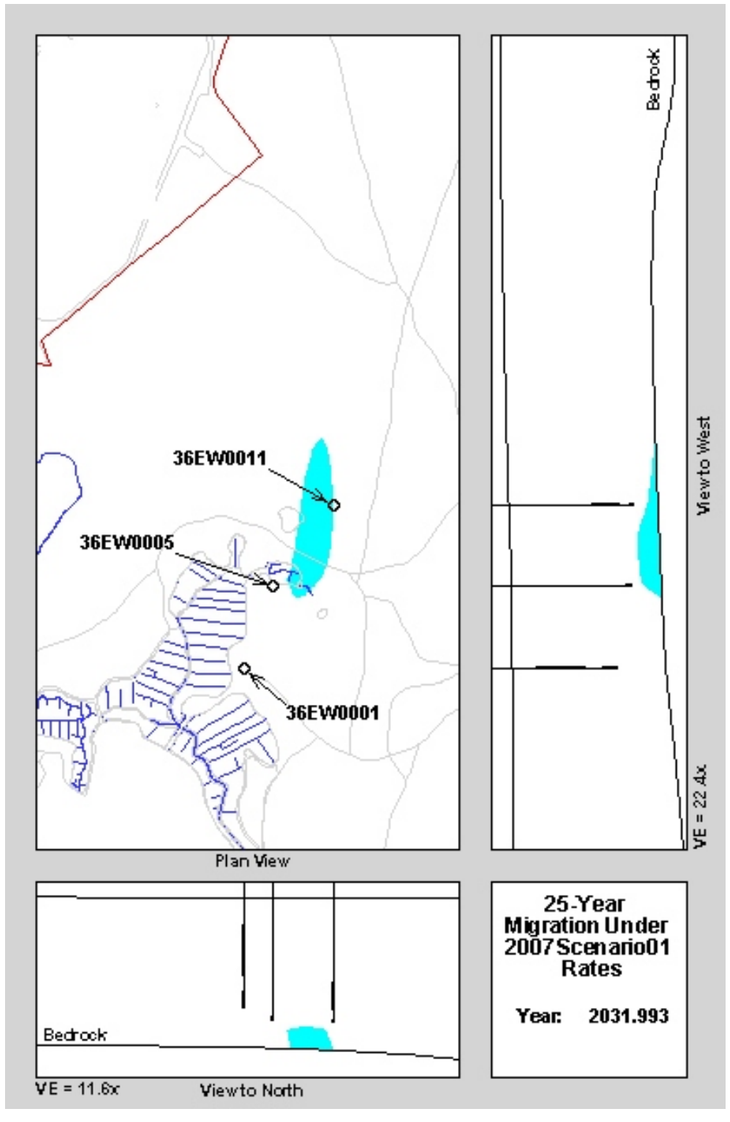
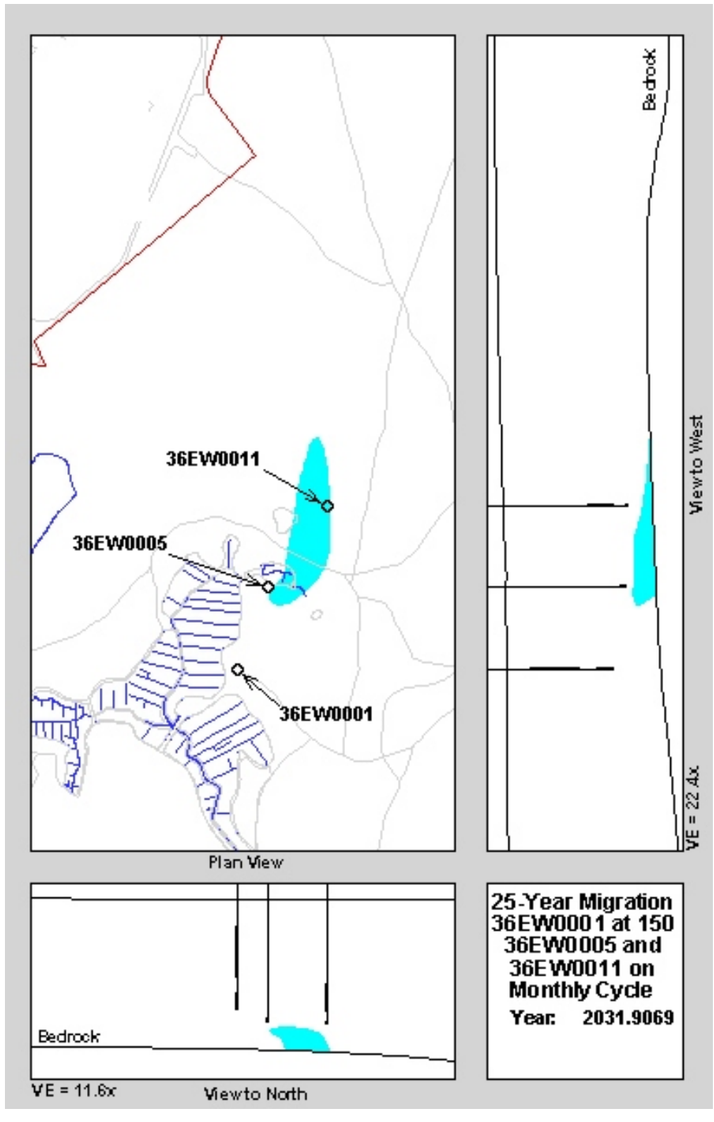
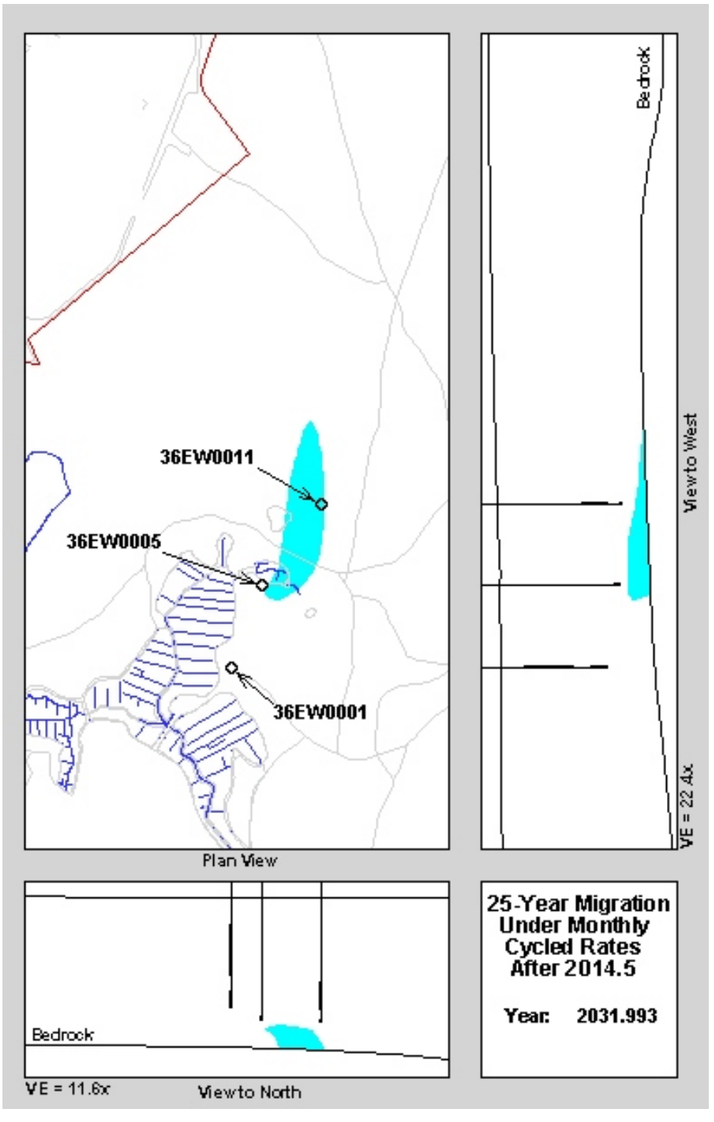
2007 Scenario 01



Cyclic Scenario CP-04



Cyclic Scenario CP-06



Legend

- EDB Concentration 0.02 - 0.1 µg/L
- EDB Concentration 0.1 - 1.0 µg/L
- EDB Concentration 1.0 - 2.0 µg/L
- EDB Concentration > 2.0 µg/L

Notes:
1). Plan view, view to north, and view to west depict the highest EDB concentration in the plume relative to each view
2). Transport modeling simulation represents EDB concentrations above MMCL of 0.02 µg/L

Source: FS-1 Groundwater Model

FIGURE 2e

SIMULATED FS-1 EDB PLUME MIGRATIONS 2032

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FS-1 Cyclic Pumping Project Note

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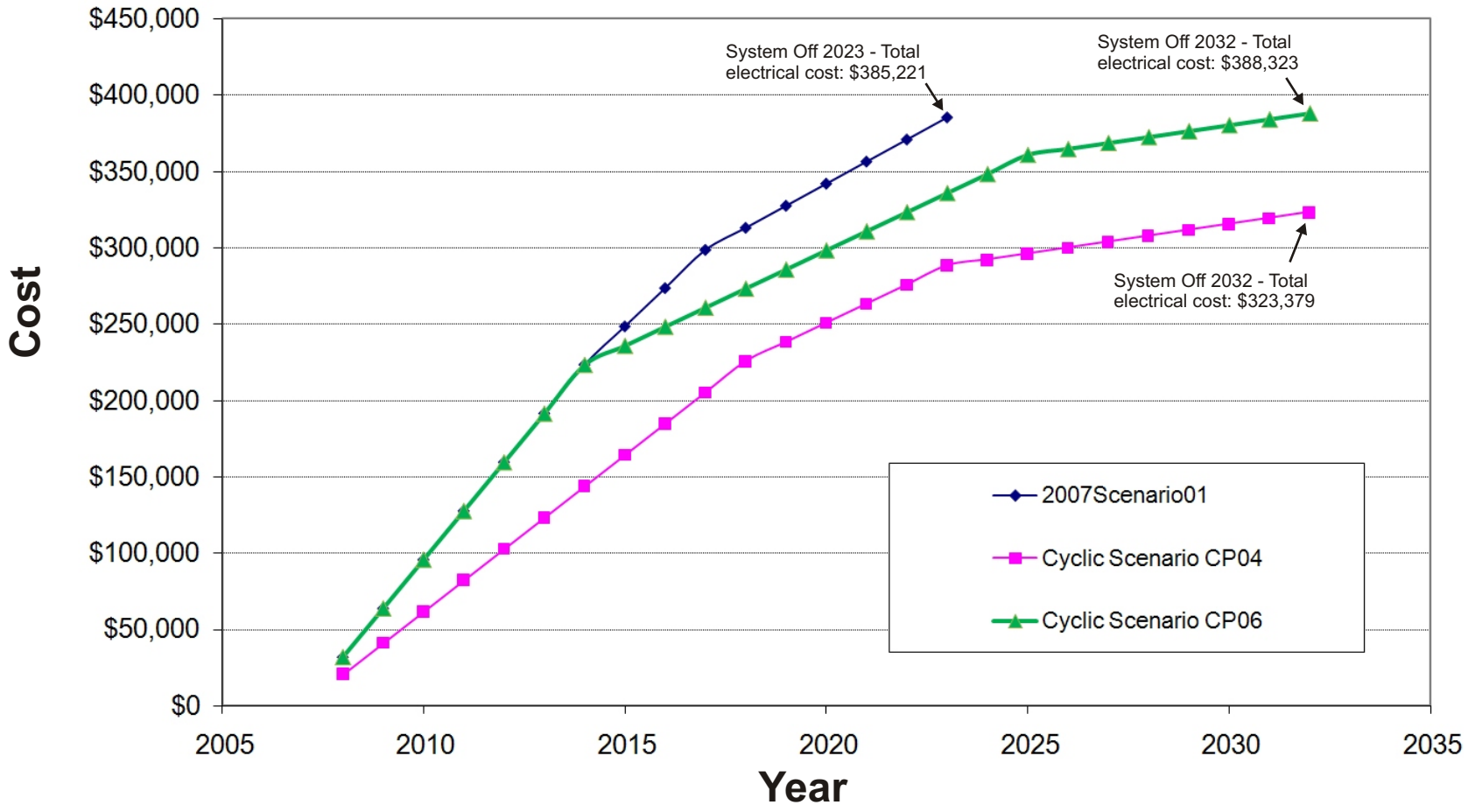

Legend

- 2007 Scenario01
- Cyclic Scenario CP04
- Cyclic Scenario CP06

FIGURE 3

CUMULATIVE ELECTRICITY COSTS

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FS-1 Cyclic Pumping Project Note

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Table 1
FS-1 Remediation System Pumping Schedule for Current and Cyclic Pumping Conditions
FS-1 Cyclic Pumping Optimization Evaluation Project Note

Location	Current (2007 Scenario 01)		Cyclic Scenario CP-01		Cyclic Scenario CP-02		Cyclic Scenario CP-03		Cyclic Scenario CP-04		Cyclic Scenario CP-05		Cyclic Scenario CP-06			
													Pre-2014		Post-2014	
	Pumping Rate (gpm)	Pumping Period	Pumping Rate (gpm)	Pumping Period	Pumping Rate (gpm)	Pumping Period	Pumping Rate (gpm)	Pumping Period	Pumping Rate (gpm)	Pumping Period	Pumping Rate (gpm)	Pumping Period	Pumping Rate (gpm)	Pumping Period	Pumping Rate (gpm)	Pumping Period
36EW0001	-90	Continuous	-90	Monthly	-90	Weekly	-90	Continuous	-150	Continuous	-150	Monthly	-90	Continuous	-90	Continuous
36EW0005	-175	Continuous	-175	Monthly	-175	Weekly	-175	Monthly	-175	Monthly	-250	Monthly	-175	Continuous	-175	Monthly
36EW0007	0	NA	0	NA	0	NA	0	NA	0	NA	-150	Monthly	0	NA	0	NA
36EW0011	-250	Continuous	-250	Monthly	-250	Weekly	-250	Monthly	-250	Monthly	-200	Monthly	-250	Continuous	-250	Monthly
Total Extraction	**-515**		**-515**		**-515**		**-515**		**-575**		**-750**		**-515**		**-515**	

Key:
CP = cyclic pumping
ft = feet
gpm = gallons per minute
msl = mean sea level
NA = not applicable

Table 2
Screen Capture and Model Outputs – 5-Year Time Step
Preliminary Cyclic Pumping Simulations
FS-1 Cyclic Pumping Optimization Evaluation Project Note

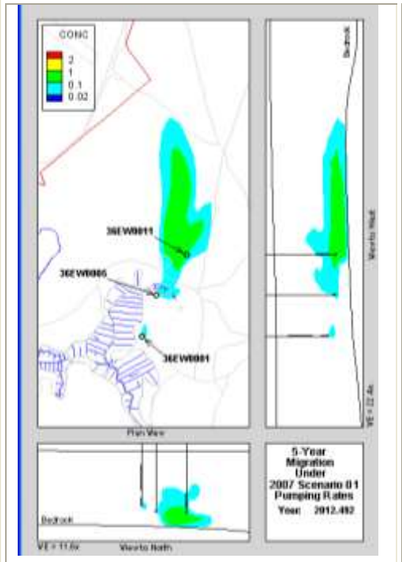
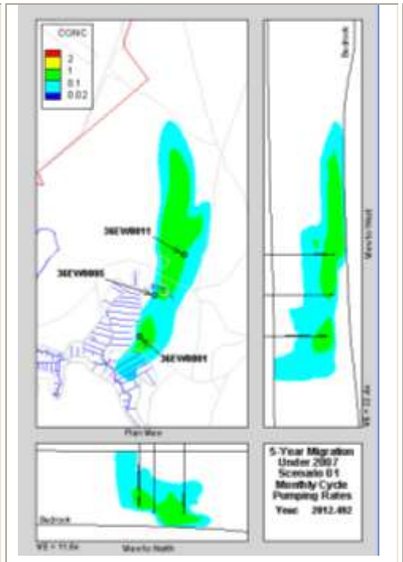
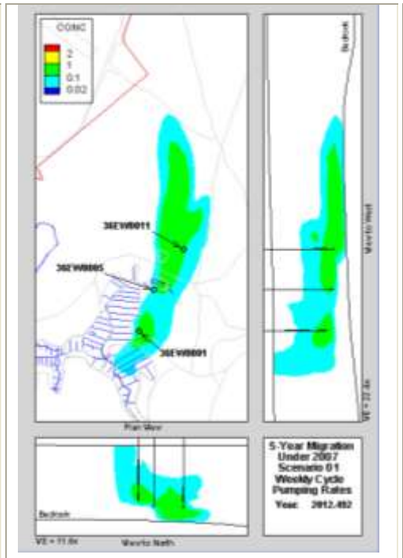
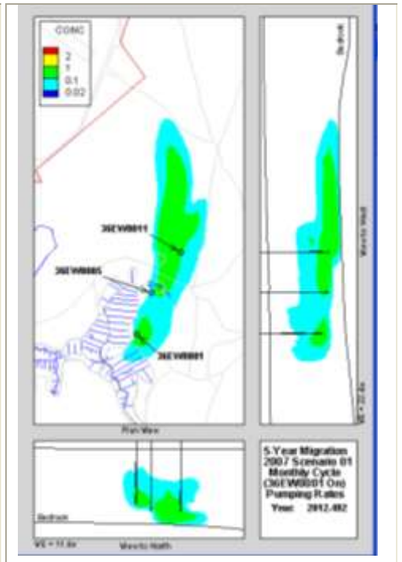
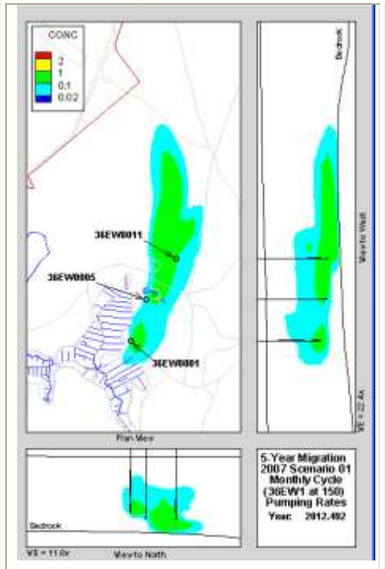
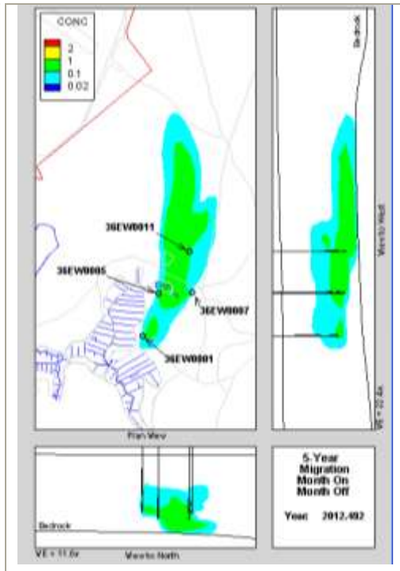
2007Scenario01	CP01 – all wells monthly	CP02- all wells weekly	CP03- Monthly, EW-1 on at 90 gpm	CP04-Monthly, EW-1 on at 150	CP05- All 4 wells monthly, wellfield design
					
Mass Removed (lbs): 1.08	Mass Removed (lbs): 0.92	Mass Removed (lbs): 0.91	Mass Removed (lbs): 0.95	Mass Removed (lbs): 0.97	Mass Removed (lbs): 0.96
Mass to Bogs (lbs): 0.012	Mass to Bogs (lbs): 0.026	Mass to Bogs (lbs): 0.028	Mass to Bogs (lbs): 0.016	Mass to Bogs (lbs): 0.013	Mass to Bogs (lbs): 0.015
Annual Electrical costs ($): 24,407	Annual Electrical costs ($): 12,203	Annual Electrical costs ($): 12,203	Annual Electrical costs ($): 13,429	Annual Electrical costs ($): 15,577	Annual Electrical costs ($): 20,797
36EW0001 - 90 full time	36EW0001 - 90 monthly	36EW0001 - 90 weekly	36EW0001 - 90 full time	36EW0001 - 150 full time	36EW0001 - 150 monthly
36EW0005 – 175 full time	36EW0005 - 175 monthly	36EW0005 - 175 weekly	36EW0005 - 175 monthly	36EW0005 - 175 monthly	36EW0005 - 250 monthly
36EW0007 - 0	36EW0007 - 0	36EW0007 - 0	36EW0007 - 0	36EW0007 - 0	36EW0007 - 150 monthly
36EW0011 – 250 full time	36EW0011 - 250 monthly	36EW0011 - 250 weekly	36EW0011 – 250 monthly	36EW0011 - 250 monthly	36EW0011 - 200 monthly

Table 3
Pumping Schedule and Model Outputs - 25-Year Time Step
FS-1 Cyclic Pumping Optimization Evaluation Project Note

Well	Flow (gpm)	Operation (Days/yr)	Year Off
2007Scenario01			
36EW0001	90	365	2014
36EW0005	175	365	2017
36EW0007	0	0	
36EW0011	250	365	2023
Mass Removed (lbs): 1.19			
Mass to Bogs (lbs): 0.014			
ETD System Off: 2023			
Cyclic Scenario CP04			
36EW0001	150	365	2018
36EW0005	175	182	2032
36EW0007	0	0	
36EW0011	250	182	2023
Mass Removed (lbs): 1.53			
Mass to Bogs (lbs): 0.028			
ETD System Off: 2032			
Cyclic Scenario CP06			
Pumping scenario **through** 2014.			
36EW0001	90	365	2014
36EW0005	175	365	
36EW0007	0	0	
36EW0011	250	365	
Pumping scenario **after** 2014.			
36EW0001	0	0	
36EW0005	175	182	2032
36EW0007	0	0	
36EW0011	250	182	2025
Mass Removed (lbs): 1.18			
Mass to Bogs (lbs): 0.021			
ETD System Off: 2032			

Key:
CP = cyclic pumping
ETD = extraction, treatment, and discharge
gpm = gallons per minute
lbs = pounds
yr = year

ATTACHMENT A

FS-1 Cyclic Pumping Optimization Simulations

(Available Upon Request)